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RESEARCH LABORATORY

FINAL TECHNICAL REPORT

CHEMICAL CORROSION OF ROCKET LINER MATERIALS AND PROPELLANT PERFORMANCE STUDIES

THEMODYNAMIC PROPERTIES OF HEAVY METAL SPECIES

VOLUME TWO OF TWO

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SECTION 1

INTRODUCTION AND DESCRIPTION OF METHODS USED

As part of a study of the chemical corrosion of rocket liner materials, Aeronutronic has carried out many computations of the chemical equilibria between rocket liner materials and corrosive gaseous or condensed materials. These computations required a knowledge of the thermodynamic properties of all the chemical species involved in each equilibrium over the temperature range 298 to 6000°K. Wherever possible, the thermodynamic properties were taken directly from the literature, such as the JANAF Interim Thermochemical Tables[1]. However, in many cases it became necessary to develop thermodynamic properties for species not found in the literature. These properties were published in the quarterly reports as they were developed[2].

As a convenience to readers, who may be interested in the thermodynamic properties for their own sake, all the properties developed during the contract period are collected in this single volume

For each species considered, the literature was searched to uncover whatever data were available; these were then evaluated in an attempt to use the most reliable data. For most species direct experimental results were lacking in some particular, and judicious estimates of the missing data were required.

For gaseous species where the requisite molecular constant data were available, thermodynamic functions were calculated by standard statistical

thermodynamic methods. Where molecular constant data were not available, they were estimated from bond angles, bond distances, and appropriate valence force equations. For the larger, more complicated molecules of uncertain structure, heat capacities and entropies were estimated by analogy with values for related molecules. Heats of formation were estimated from bond energy considerations.

For condensed species the statistical thermodynamic approach for evaluating thermodynamic properties is not useful. The methods of Kubaschewski and Evans[26] are quite applicable and have been used extensively in this work The reader should, however, be warned that relatively little good thermodynamic data exists on heavy metal species so that the results are in many cases more questionable than desired. No attempt has yet been made to access the uncertainty in the results.

Refractory solid compounds in particular are difficult to characterize thermodynamically, as such materials are "compounds" in a somewhat more restricted sense than condensed species usually considered in rocket performance calculations. These compounds exist over a considerable range of composition, and generally exhibit complex behavior on melting or vaporizing. The thermodynamic data for solids such as these are generated, based on what are considered to be reasonable procedures, but no claim is made as to exhaustive treatment of the various systems. Only a single compound of each type has been considered. Obviously, very little of the information obtained by phase diagram studies can be included with this approach.

The particular assumptions, estimates, etc. associated with the individual species are discussed in the following.

SECTION 2

DISCUSSION OF INDIVIDUAL SPECIES

2.1 TANTALUM SPECIES

2.1.1 Ta(g)

The heat of formation (186.8 kcal/mole) was taken from Stull and Sinke[3]. Enthalpy and entropy values were taken directly from the compilation of Barriault et al.[4]

2.1.2 Ta(c)

Entropy (9.90 e.u.) was chosen from Stull and Sinke[3]. The heat capacity to the melting point (5.90 + 0.00043T cal/mole^{o}K) was based on published data[3]. Stull and Sinke's reported data were also used to estimate a melting point of 3270^{o}K and a heat of fusion of 7.5 kcal/mole. The heat capacity for molten tantalum between 3270 and 6000^{o}K was estimated to be 8.0 cal/mole^{o}K based on corresponding values for similar elements.

2.1.3 TaO(g)

The heat of formation (50 kcal/mole) was calculated from the dissociation energy determined by Inghram et al[5], and the heat of formation of Ta(g), taken from Stull and Sinke[3]. Thermodynamic functions were calculated using the ground state vibrational frequency of 926 cm^{-1} estimated by Brewer[6], a bond distance of 1.825Å[7], and a moment of inertia of 8.14 x 10^{-39} gm-cm^{2}.

2.1.4 TaO_2(g)

Frequencies used were 864, 244(8) and 935 cm^{-1} as given by Brewer[6]. A linear structure was assumed and an interatomic distance the same as that

for TaO; the moment of inertia was calculated to be 17.7×10^{-39} gm-cm^2. The heat of formation (-41 kcal/mole), was estimated from experimentally measured atomization energies[5].

2.1.5 Ta_2O_5(c)

The heat of formation (-488.8 kcal/mole) was taken from Humphrey[9]. The entropy of the solid (34.2 e.u.) was taken from the compilation of Kelley[10]. Using the enthalpy values of Orr[11], the heat capacity equation $37.00 + 6.56 \times 10^{-3}T - 5.92 \times 10^5 T^{-2}$ cal/mole°K was developed. Values for the melting point (2150°K), the heat of fusion (36.120 kcal/mole) of the solid, and the heat capacity (56 cal/mole°K) of the liquid were taken from the work of Inghram[5].

2.1.6 TaF(g)

The average bond energy for TaF(g) was estimated using the bond energy (B.E.) of TaCl(g) and the inverse square law of Somayajulu[12]

$$B.E._{TaF(g)} = B.E._{TaCl(g)} \times \left[\frac{r_{TaCl}}{r_{TaF}}\right]^2$$

A bond energy of 106 kcal/mole for TaCl(g) and bond distances of 2.3 and 1.95Å [13] were taken for TaCl(g) and TaF(g), respectively. Using the known heats of formation of gaseous fluorine and tantalum and the estimated bond energy of TaF(g), a heat of formation of 60.7 kcal/mole was calculated. The moment of inertia was calculated to be 10.85×10^{-39} gm.-cm.^{2}, based on an interatomic distance of 1.95Å. The wave number was calculated to be 545 cm.$^{-1}$, from a force constant of 3×10^5 dynes/cm. This force constant was the average of calculations made using the method of Varshni[14] (2.76×10^5 dynes/cm.) and Somayajulu[12] (3.27×10^5 dynes/cm.).

2.1.7 TaF_2(g)

A heat of formation of -65.5 kcal/mole was calculated in the same way as was done for TaF(g). A moment of inertia of 23.98×10^{-39} gm.-cm.^{2} was obtained, using the TaF(g) interatomic distance. Use of the TaF(g) stretching force constant and a bending force constant of 0.3×10^5

dynes/cm.^{5} yielded wave numbers: 254(2), 518, and 570 cm.$^{-1}$.

2.1.8 $TaF_3(g)$

In the same manner used to calculate ΔH^{o}_{298} and I for TaF(g), the corresponding values for $TaF_3(g)$ were found to be -192 kcal/mole and 1.075×10^{-113} gm.^{3}-cm.^{6} (product of moments of inertia about the three coordinate axes using an assumed pyramidal structure). Assuming a 55° angle between the axis of symmetry of the pyramid and an edge, the same force constant used for $TaF_2(g)$, and assuming the valence force theory[15], the wave numbers were calculated to be 237(2), 251, 545(2) and 546 cm.$^{-1}$.

2.1.9 $TaF_4(g)$

Heat of formation and moment of inertia were calculated in the same manner as was used for TaF(g); symmetric tetrahedral structure was assumed. These results gave ΔH^{o}_{f298} =-318 kcal/mole and $I_x I_y I_z = 3.27 \times 10^{-113}$ gm.^{3}-cm.^{6}. The valence force theory gave the wave numbers: 257(3), 282(2), 518 and 554(3)cm.$^{-1}$.

2.1.10 $TaF_5(g)$

A heat of formation of -444 kcal/mole was calculated in the manner used for TaF(g). From a plot of entropy versus molecular weight for known tantalum halides and oxyhalides and niobium chlorides and oxychloride, S^{o} at 298°K for $TaF_5(g)$ was estimated to be 81 e.u. By extrapolating plots of C_p versus valence for TaF species, values of heat capacity were obtained and fitted to derive the following function:

$$C_p(T) = 31.00 + 10.17 \times 10^{-3}T - 0.507 \times 10^{6}T^{-2} \text{ (cal/°K mole)}$$

2.1.11 TaCl(g)

Good agreement was obtained from two independent methods for estimating the force constant. Using an interatomic distance of 2.30Å [13], the method of Varshni [14] gave 1.91 x 10^5 dynes/cm (2.904 and 0.203 were used for the constants a and b, respectively), while that of Somayajulu[12] gave 2.02 x 10^5 dynes/cm. The vibrational frequency (335 cm^{-1}) based on an average of these force constants was used in the calculation. The moment of inertia was calculated to be 26.1 x 10^{-39} gm-cm^2. The heat of formation was calculated to be 110 kcal/mole, from the values for $TaCl_5$ reported by von Schafer,[16] assuming the Ta-Cl bond energy to be independent of the valence state of tantalum.

2.1.12 $TaCl_2$(g)

Based on an assumed linear structure, the interatomic distance and force constant used for TaCl, and the second force constant of $TiCl_4$ (0.1 x 10^5 dynes/cm), the vibrational frequencies were calculated to be 305, 115(2) and 360 cm^{-1}. The moment of inertia was calculated to be 62.4 x 10^{-39} gm-cm^2. The heat of formation was computed in the same manner as for TaCl and found to be 33 kcal/mole.

2.1.13 $TaCl_3$(g)

A pyramidal structure was assumed, with a TaCl bond distance of 2.30Å. The angle between an edge of the pyramid and the axis of symmetry was calculated to be 58°, using the valence force theory. The product of the three moments of inertia was calculated to be 124 x 10^{-114} gm^3-cm^6. With the same force constants which were used for $TaCl_2$(g), the following vibrational frequencies were calculated: 108, 332, 104(2) and 338(2) cm^{-1}. The heat of formation (-44 kcal/mole) was calculated assuming the same bond energies as derived from the heat of formation of $TaCl_5$(g) reported by von Schafer[16].

2.1.14 $TaCl_4(g)$

Heat of formation (136 kcal/mole) and entropy (92 e.u.) were taken from estimates by von Schafer and Kahlenberg[16]. Their estimated heat capacity equation, $25.8 - 2 \times 10^5 T^{-2}$ cal/mole°K., was used throughout the temperature range (298 - 6000°K).

2.1.15 $TaCl_3(c)$ and $TaCl_4(c)$

Heats of formation, entropy and heat capacity for these species were both estimated by von Schafer and Kahlenberg[16], and are tabulated below. Use of the heat capacity functions to 6000°K must be considered a rough approximation until further data becomes available.

Species	ΔH°_{f298} (kcal/mole)	S_{298} (e.u.)	C_p(cal/mole°K)
$TaCl_3(c)$	-130.5	37.	$23.0 + (3.9)\ 10^{-3} - (1.7)\ 10^5 T^{-2}$
$TaCl_4(c)$	-168.8	46.	$31.9 - 2.9 \times 10^5 T^{-2}$

2.1.16 $TaCl_5(g)$

Values of heat of formation (-183 kcal/mole), entropy (100 e.u.) and heat capacity ($31.6 - 3.7 \times 10^5 T^{-2}$ cal/mole°K) were used as reported by von Schafer and Kahlenberg[16].

2.1.17 TaC/c

Huber's[18] value for the standard heat of formation, -34.6 + 0.9 kcal/mol was used. This value, being more recent, is presumably better than the value of -38.5 ± 0.6 published by Humphrey[19] in 1954. Kelley's[20] value for entropy, S°_{298}, of 10.11 e.u./mole was used. Mezaki[21] gives 10.10 ± 0.2, in essential agreement. The melting point was taken as 4100°K, as given in NBS 500[22] (Zalabak[23] found a maximum of 4030°K with decomposition.) Schwarzkopf and Kiefer[24] quote 3800°C, based on the 1943 work of Ellinger[25].

Kubaschewski[24] and Evans[26] point out that entropies of fusion for inorganic compounds lie in the range of 1.4 (CaF_2) to 3.3 ($HgBr_2$)e.u. per gram atom. A value of 2.5 was used for both TiC and TiN by the JANAF groups[1]; for ZrC and ZrN a roughly equivalent value was used. Thus in the absence of better data, the entropy of fusion is estimated as 5.0 entropy units for TaC. The heat of fusion follows directly as 20.5 kcal/gm-atom.

Experimental specific heat measurements on TaC are given by Kelley[20] at low temperatures, and by Mezaki[21](Wisconsin), Neel et al[27] (Southern Research Institute), and by Barriault et al[4] (AVCO), at high temperatures. The "additivity" approach is often used to estimate the heat capacity of refractory compounds; this consists of simply adding the data for the individual elements. The experimental data and the"additivity" data were compared on a "Shomate"[17] plot, and an averaged line selected, leading to the equation.

$$C_p = 10.015 + 2.60 \times 10^{-3}T - 1.776 \times 10^{5}T^{-2}$$

This equation was used to 2200°K above which point the Southern Research data indicate Cp is constant at 15.8 cal/mole-°K. Heat capacity of the liquid above 4100°K was also assumed to be 15.8 cal/mole-°K.

2.1.18 TaN/c

The heat of formation of tantalum nitride was taken as -60.0 ± 0.6 kcal/mol, as given by Mah and Gilbert[28]. The entropy at 298°K is given by Mezaki[21],as 12.4 ± 2.0, whereas Kubaschewski[26] gives 12.2 ± 1.0. The value of 12.2 was used. The melting point was taken as 3363°K, as given by Kunaschewski[26]. Assuming 2.5 e.u./gm-atom, as was done for TaC and as was done by JANAF[1] for ZrN, the entropy of fusion is 5.0 e.u., the heat of fusion following directly as 16.816 kcal/mol.

Kelley[20] gives for molar specific heat, the equation:

$$C_p = 7.73 + 7.80 \times 10^{-3}T \qquad 298\text{-}800°K$$

This equation gives Cp = 10.05 at 298°; NBS 500[22] gives 9.7. No high temperature heat content data for TaN are given by Neel[27] or by Mezaki[21], but Neel[27] gives data on HfN which shows an apparent peak in heat capacity at 1000-1100°K of 15.0 cal/mol-°K, and an overall average to about 2800°K of 13.8. (The drop off with temperature above this value seems unreasonable.) Kelley's equation at 1000°K would give a value of 15.53, but this is presumably high because of the extrapolation of the linear relationship involved. JANAF values for Cp of ZrN, which would be expected to be somewhat lower than for TaN, are for example, 12.6 at 1000°, 14.4 at 2000°, and 16.1 at 3000°K. As no good technique for combining these various fragments of information appeared to be evident, an arbitrary approach was used, in which Kelley's equation was used to 934°K, at which point Cp = 15.0; above 934°K the specific heat was held constant at this value.

2.1.19 TaB_2/c

Brewer and Haraldsen[29] give limits on heats of formation for various borides. Leitnaker[30] reviews these data in light of his own experiments, and gives the ΔH°_{f298} for TaB_2 as

$$-126.0 < H^\circ_{f298}\ (TaB_2) < -45.5$$

Brewer[29] gives the limit as -26 kcal/mole boron or <-52 for ΔH°_{f298} of TaB_2. Miller[31] quotes Samsonov[32] as reporting -45 kcal/mole. Quite obviously considerable uncertainty exists; a value of -50 was selected. The heat of formation of ZrB_2 has been reported as -71.61[33] very recently, a value less negative than -76 as used by JANAF, and on which considerations of boride heats of formation have been based.

Margrave et al[34] give the entropy of TaB_2 at 298°K as 11.3 e.u. This is derived by noting Westrum's[35] experimental value for ZrB_2 or 8.59, whereas the sum of the constituents would be 12.1; the boron entropy contribution is thus apparently -1.8 e.u./B atom. On the same assumption,

but using a tantalum metal entropy of 9.90 based on our previous tabulation (2.1.2) and the non-rounded value of -1.75 as the boron contribution, a figure of 9.18 e.u. is calculated. This was the value used. According to Schwarzkopf[24], TaB_2 decomposes before it melts, at about 3000°C. Aronson[36] lists a value for the melting point of 3200°C (3470°K), the value selected. Based on 2.5 e.u./gm-atom as the entropy of fusion, the entropy of fusion is 7.5 e.u., and the heat of fusion follows as 26.025 kcal. Mezaki[21] gives heat content data for TaB_2 to 1200°K, and provides a heat capacity equation linear in temperature. Neel[27] gives heat content data for "TaB" but its composition was not specified; the data were not used. The enthalpy data of Mezaki were used by noting the ratio of measured enthalpies to the predicted enthalpies based on additivities of the elements, as follows:

T, °K	Additivity	Mezaki[21]	Ratio
500	2.750	3.002	1.092
700	5.961	6.330	1.061
900	9.462	10.008	1.058
1100	13.178	14.036	1.065
1200	15.101	16.182	1.072
2000	31.512	--	--

The significance of the minimum in the ratio is doubtful. The procedure used was to assume a value of 1.07, and assign an enthalpy at an arbitrarily selected 2000°K of 1.07 x 31.512 or 33.718. An enthalpy equation was then derived by using values at 298.16° (the zero), 700°K, 1200°K, and 2000°K in the form

$$H_{298}^{T} = aT + \frac{b}{2}T^2 - \frac{c}{T} + K$$

The resulting equation gave specific heat as follows:

$$C_p = 18.294 + .0C247T - 7.879 \times 10^5 T^{-2}$$

which was used to 2000°K; above this temperature the heat capacity was held constant at 23.0 cal/°K-mol.

2.1.20 TaOF(g) and TaOCl(g)

The following values of bond distances and force constants were taken from previous estimates (2.1.3, 2.1.11, 2.1.6) and used in the valence force theory equations[15] to obtain moments of inertia and wave numbers:

	bond distance (Å)	$k(\frac{dynes}{cm.})$	$k/\ell^2\ (\frac{dynes}{cm.})$
Ta-O	1.827	7.42×10^5	0.14×10^5
Ta-Cl	2.30	1.95×10^5	0.1×10^5
Ta-F	1.95	3.0×10^5	0.3×10^5

Values of the effective bending force constants for linear TaOCl(g) and TaOF(g) were calculated from the equation[37]:

$$\left[\frac{k_\delta}{l_1 l_2}\right]_{eff} = \frac{2 l_1 l_2 \left[\frac{k_{\delta_1}}{l_1^2}\right] \cdot \left[\frac{k_{\delta_2}}{l_2^2}\right]}{l_1^2 \left[\frac{k_{\delta_1}}{l_1^2}\right] + l_2^2 \left[\frac{k_{\delta_2}}{l_2^2}\right]}$$

where:

$\left[\frac{k_\delta}{l_1 l_2}\right]_{eff}$ is the effective bending force constant for the two bonds of lengths

$\left[\frac{k_{\delta_1}}{l_1^2}\right]$ is the bending force constant for bond 1.

$\left[\frac{k_{\delta_2}}{l_2^2}\right]$ is the bending force constant for bond 2.

From these constants the moments of inertia for TaOF and TaOCl were calculated to be 20.82×10^{-39} and 38.08×10^{-39} gm.cm.^{2}, respectively. Wave numbers for TaOF were 208.5(2), 540, and 926 cm.$^{-1}$. For TaOCl the corresponding wave numbers were 157(2), 331, and 926 cm.$^{-1}$.

2.1.21 $TaO_2Cl(g)$, $TaO_2F(g)$, $TaOF_2(g)$, $TaOCl_2(g)$ and $TaOF_3(g)$

Thermodynamic properties for these species were estimated from bond energies, additivity laws, and correlations with compounds including the species TaOCl(g), TaOF(g) and $TaOCl_3(g)$ reported herein. Procedures

used are outlined below:

The heats of formation were obtained from bond energies based on the heats of formation of $TaCl_3(g)$, $TaF_3(g)$, $TaO(g)$ and $TaO_2(g)$, the heat of sublimation of Ta(s), and the JANAF values of the dissociation energies of $F_2(g)$ and $Cl_2(g)$. An independent check of this method for the tantalum oxyhalides was made by calculating the heat of formation of $TaOCl_3(g)$ (-180.7 kcal/mole), and comparing the result with Schafer's[38] reported value (-187.2 kcal/mole).

Again, entropies at 298°K were obtained from a graphical correlation of compounds of tantalum and niobium following the method of Kubaschewski[26].

By adding up the component heat capacities of the tantalum oxyhalides from $TaO(g)$, $Cl_2(g)$ and $F_2(g)$, heat capacities of the individual oxyhalides were estimated at various temperatures. The calculation of thermodynamic functions subsequently made use of these heat capacities fitted to the general equation

$$C_p(T) = A + BT + CT^{-2}$$

Table I summarizes the results from the foregoing calculational methods.

TABLE I

Species	ΔH°_{f298} (kcal/mole)	S°_{298} (e.u.)	$C_p(T) = A + BT + CT^{-2}$ cal/mole°K		
			A	$Bx10^3$	$-Cx10^{-6}$
$TaO_2Cl(g)$	-117.9	69.5	19.01	0.1320	0.3087
$TaO_2F(g)$	-167.2	71.0	18.95	0.1734	0.3322
$TaOF_2(g)$	-202.5	72.5	17.52	0.2655	0.2391
$TaOCl_2(g)$	-103.8	74.0	17.64	0.1826	0.1922
$TaOF_3(g)$	-335.3	76.0	21.92	0.3818	0.2994

2.1.22 $TaOCl_3(g)$

Estimates by von Schafer and Sibbing[38] of the heat of formation (-187.2 kcal/mole) and entropy (86.4 e.u.) were used. Heat capacity was estimated by summing the contributing heat capacities of TaO(g) and 3/2 $Cl_2(g)$. The resulting data was approximated by the equation $C_p = 19.6 + 0.00413T$ (cal/mole°K) from 298 to 1000°, and $22.5 + 2.2 \times 10^{-4}T$ from 1000 to 6000°K.

2.2 TUNGSTEN SPECIES

2.2.1 $WF_2(g)$

A heat of formation of -3.3 kcal/mole has been estimated from the average WF bond energy in $WF_6(g)$[39]. A linear structure with W-F distance of 1.89Å was assumed[13]. The corresponding moment of inertia was calculated to be 22.6×10^{-39} gm-cm^2. Fundamental frequencies of 526, 147(2) and 578 cm^{-1} were estimated by the valence bond method[15] using a stretching force constant of 3.1×10^5 dynes/cm, and bending force constant of 0.1×10^5 dynes/cm.

2.2.2 $WF_4(g)$

A heat of formation of -210 kcal/mole has been estimated, using the average W-F bond energy in $WF_6(g)$[39]. Using the same force constants as for WF_2, fundamental frequencies of 526, 164(2), 561(3) and 149(3) cm^{-1} were estimated. A tetrahedral structure was assumed, with a W-F bond distance of 1.89Å [13]; the product of the moments of inertia was calculated to be 27.2×10^{-114} gm^{3}cm^6.

2.2.3 $WF_5(g)$

A heat of formation of -384 kcal/mole was estimated, using the bond energies of WF(g), $WF_6(g)$ and $WOF_4(g)$. These latter bond energies were determined from the JANAF heats of formation of these compounds. An entropy of 85 e.u. was estimated from values of S°_{298} for the gaseous species WF, WF_2,

WF_4 and WF_6. Heat capacities for $WF_5(g)$ were estimated by cross-plotting values of C_p for these same tungsten fluorides at various temperatures, and fitting to the equation $C_p = A + BT - CT^{-2}$. The resulting heat capacity function between 298°K and 6000°K was taken as:

$$C_p(T) = 30.805 + 3.69 \times 10^{-5} T - 5.42 \times 10^{5} T^{-2} \text{ (cal/mole-°C)}$$

2.2.4 $WO_2F_2(g)$ and $WOF_2(g)$

By analogy and correlation of the values of entropy and molecular weight for other tungsten compounds, estimates for the entropy at 298°K for $WO_2F_2(g)$ and $WOF_2(g)$ were taken to be 74 and 70 e.u., respectively. Heats of formation from bond energies were calculated to be -246 kcal/mole for $WO_2F_2(g)$ and -96 kcal/mole for $WOF_2(g)$. Bond energies used in these calculations were derived from JANAF values for the heats of formation of F(g), W(g), WO(g), $WO_2(g)$, O(g), WF(g) and $WF_6(g)$. The additivity assumption used to obtain heat capacities was found to give results which checked reasonably well with JANAF values for $WO_2Cl_2(g)$. Heat capacity functions at temperatures between 298°K and 6000°K were found to be:

$$C_p(T) \text{ for } WO_2F_2(g) = 22.44 + 0.2748 \times 10^{-3} T - 0.375 \times 10^{6} T^{-2} \text{ (cal/mole-°K)}$$

$$C_p(T) \text{ for } WOF_2(g) = 17.60 + 0.2548 \times 10^{-3} T - 0.229 \times 10^{6} T^{-2} \text{ (cal/mole-°K)}$$

2.2.5 WC(c)

Schwarzkopf and Kieffer[24] describe reactions of tungsten and carbon in detail. The only tungsten-carbon compound which appears to have been described thermodynamically is WC; this is the species considered. However, the simplification introduced by treating only a single carbide is evident by considering the work of Sara and Doloff[40] at National Carbon. The WC system, like most metal-carbon systems, is complex, and neither W_2C nor WC are stable compounds, as such, to the melting points. The composition

corresponding to W_2C first forms a liquid phase at 2760°C; this composition does not completely melt until about 2790°C. The composition corresponding to WC dissociates at 2730°C into W_5C_3 and C prior to melting. An α-WC goes to β-WC at 2755°C. The first liquid forms at 2785°C. The temperature corresponding to complete melting, at the composition corresponding to WC, was not measured, but was apparently considered by them (judging the sketched in portion of the phase diagram) to be at 2890°C or 3160°K, in good agreement with an older value of 3140°K.[22] A number of other quite different values have also been reported[24].

Kubaschewski[26] gives the heat of formation of WC at 298°K as -9.1 ± 2.5 kcal/mole. McGraw and coworkers[41] data, corrected to the JANAF value for WO_3(s), give a ΔH_f^o value of -9.7 ± 0.9. The latter value was selected. Kubaschewski[26] gives the entropy at 298°K as 8.5 ± 1.5 e.u. A value of 9.19 is estimated, based on additivities, but values based on additivities tend to be somewhat high. (Thus, based on JANAF values, S^o_{298} for TiC is 5.803 vs. 8.689 by additivities; S^o_{298} for ZrC is 9.30 vs. 10.669 by additivities.) The value of 8.5 was used.

The melting point was assigned at 3160°K, corresponding to the temperature of complete liquefaction given by Sara and Doloff[40]. Entropy of fusion was again taken as 5.0 e.u., giving a heat of fusion of 15.8 kcal/mol.

Kubaschewski[26] gives the heat capacity equation

$$C_p = 7.98 + 2.17 \times 10^{-3}T \qquad 298\text{-}3000^\circ K$$

claiming accuracy to 6 percent. At 298°K this equation gives $C_p = 8.63$; the additivities rule gives 7.835. Boosz[58] gives heat capacity of tungsten carbide as 6.85, but the abstract did not define the stoichiometry. The JANAF tables permit estimation of heat capacity by the additivity rule for comparison with Kubaschewski's equation, as follows:

WC Heat Capacity by Additivities

T,°K	C_p(W)	C_p(C)	C_p(WC)	C_p(Kubaschewski)
298	5.797	2.038	7.835	8.63
300	6.114	3.496	9.610	9.06
1000	6.547	5.149	11.696	12.15
1500	6.920	5.669	12.589	13.23
2000	7.286	5.865	13.151	14.32
2500	7.648	5.974	13.622	15.40
3000	8.009	6.057	14.066	16.49

The two results agree within about 10 percent. The additivity values based on JANAF data were selected, and fitted at 298, 1000 and 3000°K, to give the following equation:

$$C_p = 11.375 + .00091T - 3.388 \times 10^5 T^{-2}$$

Above 3160°K, heat capacity was assumed constant at 14.5 cal/°K-mol.

2.2.6 WB(c)

Leitnaker[30] estimates the heat of formation of WB as between -15 and -12 kcal/mole. A value of -13.5 was chosen. The entropy was estimated from the JANAF entropies for W and B, assuming a B contribution of -1.75 e.u. as before, resulting in a value of 7.47 e.u. Schwarzkopf and Kieffer[24] give a melting point of 2860°C; a value of 3130°K was used. Aronson[36] gives a melting point for W_2B_5 of only 2200°C, implying some doubt of the 2860°C value for WB; no value is given by Aronson for the WB compound, however. Assuming 2.5 e.u./gm atom as the entropy of fusion as before, the heat of fusion follows at 15.65 kcal/mol.

Mezaki's [21,34] data were again used in the under 1200°K region, and extended to 2000° by empirical correction of additivities as follows:

T, °K	Additivity	Mezaki	Ratio
500	1.968	2.061	.955
700	4.201	4.459	.942
900	6.605	6.953	.950
1100	9.139	9.475	.965
1200	10.448	10.738	.973
2000	21.612	(20.964)	

Again the trend is noted but was not deemed convincing; an enthalpy value at 2000° of .97 x 21.612 or 20.964 was used, as with TaB_2. The C_p equation resulting was

$$C_p = 13.129 - .162 \times 10^{-3}T - 4.26 \times 10^{5}T^{-2}$$

This equation has a maximum at 1770°K; above 1800°K C_p was assumed to increase linearly to a value of 14.0 at the melting point.

2.3 HAFNIUM COMPOUNDS

2.3.1 Hf(g)

The heat of formation, 145.5 kcal/mole, was taken from Panish and Reiff[54]. Values of enthalpy and entropy were taken from Barriault et al[4] (Entropy and enthalpy data at 3000°K are only 0.15 units higher than corresponding data from Kelley and King[43]. Also, Poland et al[42] report a value for the enthalpy of 6000°K which is 0.21 kcal/mole higher than that used.)

2.3.2 Hf(c)

Data from Barriault et al[4] were used for the solid and liquid states of hafnium. The values from Kelley and King[43] at 3000°K are again slightly lower (29.54 vs. 30.23 e.u. for entropy and 26.11 vs. 27.72 kcal/mole for enthalpy). The data for the liquid were extended to 6000°K using a constant heat capacity of 8.00 cal/deg mole.

2.3.3 HfO(g)

From the bond energy calculated using the heat of formation of HfO(g), Hf(g), and O(g), the heat of formation of HfO(g) at 298°K was estimated to be 30 kcal/mole. Using the bond distance, 1.74 A, given by Brewer[44], the moment of inertia was calculated to be 7.38×10^{-39} gm-cm^2. The wave number taken from the same source was 895 cm^{-1}. A statistical weight of unity was again used for the ground state.

2.3.4 HfO_2(g)

The heat of formation of HfO_2(g) was estimated to be -85 kcal/mole at 298°K from the corresponding heats of formation of gaseous TiO_2 and ZrO_2 given by JANAF[1]. The Hf-O bond length was taken to be 1.74 A, as given by Brewer[44]. Assuming a linear structure the moment of inertia is 16.08×10^{-39} gm-cm^2. The wave numbers were taken from Chandrasekharaiah[45] to be 244(2), 860 and 935 cm^{-1}. The statistical weight of the ground state was assumed to be unity due to complete pairing of electrons.

2.3.5 HfO_2(c)

The heat of formation, -266.1 kcal/mole, and entropy at 298°K, 14.18 e.u., were taken from Kelley's work[43]. The melting point, 3170°K, was taken from Goldsmith[46] et al. The entropy of fusion was taken as 7.0 e.u./mole, based on considerations given by Kubaschewski[26], giving a heat of fusion of 19 kcal/mol.

Orr[47] gives the heat capacity equation

$$C_p = 17.39 + 2.08 \times 10^{-3}T - 3.48 \times 10^{5}T^{-2} \quad (298\text{-}1800^\circ K)$$

This equation gives a value of 21.75 cal/mole°K, or 7.25 cal/gm-atom-°C, at 2115°K. A value of 7.25 is reasonable for heat capacity at a melting or transition point[9], so that it seemed reasonable to use this value as an approximate maximum, even though the melting point is much higher (3170°K). The equation was thus used to 2115°K, above which temperature C_p was assumed to be constant at 21.8 cal/mole-°C.

2.3.6 HfCl(g)

A bond length of 2.50 A was obtained by adding the atomic radii, and multiplying the sum by the ratio of the observed Hf-Hf bond length[13] to the atomic diameter of hafnium. The moment of inertia was then calculated to be 30.7×10^{-39} gm-cm^2.

Estimation of the stretching force constant for hafnium chloride was based on the valence force theory,[15] using an observed frequency, ν_3, for $HfCl_4(g)$[48], and bending force constant determined from correlations using electrostatic theory[37]. A similar calculation was made for hafnium fluoride using an observed frequency, ν_3, for $HfF_4(g)$[48]. From these two stretching force constants, the empirical values, a and b, in Gordy's equation[49] for estimating force constants for large groups of compounds could be calculated, assuming the electronegativities of hafnium and zirconium to be equal. The stretching force constant obtained using the values a = 3.93 and b = 0.66 in Gordy's equation gives 2.54×10^5 dynes/cm for HfCl(g). This value was used to obtain 382 cm^{-1} for the wave number.

A statistical weight of 2 for the ground state was based on the presence of an unpaired electron.

The heat of formation was calculated from the measured heats of formation of $HfCl_4(g)$[50,51] Hf(g)[4], and Cl(g)[1] by assuming the change in bond energy with valence is the same as that used for the corresponding Zr and Ti halides by the JANAF committee[1]. Smoothed curves having these energy/valence slopes indicate a heat of formation at 298°K for HfCl(g) of -3 kcal/mole.

2.3.7 $HfCl_2(g)$

The same bond length used for HfCl(g) was taken from $HfCl_2(g)$. A moment of inertia of 73.6×10^{-39} gm-cm^2 was calculated, based on an assumed linear molecular structure. The bending force constant was calculated from a previously determined value for $ZrCl_2(g)$[37], by assuming that Hf and Zr have the same electronegativities and accounting for differences in bond lengths. The bending force constant was found to be

0.045×10^5 dynes/cm. Using this force constant and the stretching force constant used for HfCl(g) in equations derived from valence force theory,[15] wave numbers were calculated to be 77.6(2), 349, and 412 cm^{-1}.

A statistical weight of 1 for the ground state was used. By the same methods used for HfCl(g), the heat of formation at 298°K was found to be -86 kcal/mole.

2.3.8 $HfCl_3(g)$

A planar trigonal structure was assumed with the same Hf-Cl distance used for the diatomic species. The moment of inertia for this configuration is 336.2×10^{-114} gm^3-cm^6, and the symmetry number is 6. A statistical weight of 2 was used for the ground state.

Methods described for $HfCl_2(g)$ were used to obtain 0.037×10^5 dynes/cm for the bending force constant. An out-of-plane force constant of 0.033×10^5 dynes/cm was calculated from the following relation previously determined for $ZrCl_3(g)$[37]:

$$\frac{k_\Delta}{l^2} = 0.145\ k_1 + 0.491\ \left(\frac{k_\delta}{l^2}\right) - 0.353$$

where

$\frac{k_\Delta}{l^2}$, k_1, and $\frac{k_\delta}{l^2}$ are the out-of-plane, stretching and bending force constants respectively (dynes/cm $\times 10^{-5}$)

Using these out-of-plane and bending constants and the stretching force constant used for HfCl(g), the following wave numbers were calculated: 50.2, 80.7(2), 349, and 398(2)cm^{-1}.

The heat of formation was found to be -159 kcal/mole at 298°K by the method described for HfCl(g).

2.3.9 $HfCl_4(g)$

A tetrahedral structure was assumed with the same Hf-Cl bond length used for HfCl(g). This configuration has a moment of inertia of 944.4×10^{-114} gm^3-cm^6, and a symmetry number of 12. The statistical weight for the ground state was taken to be one. Calculations of bending force constants described for HfCl(g) give the value 0.062×10^5 dynes/cm for $HfCl_4(g)$. Using this value and the stretching force constant calculated for HfCl(g), the following wave numbers were derived from valence force theory: 91.6(3), 94.4(2), 349, and 393(3) cm^{-1}.

The heat of formation is obtained from the heat of sublimation (23.8 kcal/mole) by Palko, et al[51], and the heat of formation of $HfCl_4(c)$[50], and found to be -213.0 kcal/mole at 298°K.

2.3.10 $HfCl_4(c)$

Gross's[50] value was used for the heat of formation (236.88 ± .22 kcal/mole). Kelley's[43] value for the entropy (45.60 e.u.) at 298°K was used along with his value for the fusion of 10.5 kcal/mole at the melting point (705°K). The heat capacity equation of Orr[47] (C_p - 31.47 - $2.38 \times 10^5 T^{-2}$ cal/mole-°C, -298-485°) was used (and extrapolated) to the melting point, and a constant value of 36.2 cal.mole-°C (7.25 cal/gm-atm-°C) was used to 6000°K.

2.3.11 $HfF(g)$, $HfF_2(g)$, $HfF_3(g)$ and $HfF_4(g)$

Methods used to calculate force constants, heats of formation and moments of inertia for these species are identical to the $HfCl_x$ species. The following table summarizes the results of these computations. A bond distance of 2.22 A and a stretching force constant of 4.07×10^5 dynes/cm was used throughout.

Species	Moment of Inertia	$\frac{k_\delta}{l^2} \times 10^{-5}$ (dynes/cm)	Wave Numbers(cm^{-1})	ΔH°_{298} (kcal/mole)
HfF(g)	14.0×10^{-39} gm-cm^2	--	634	-21
HfF_2(g)	31.1×10^{-39} gm-cm^2	0.059	113(2),603,664	-143
HfF_3(g)	25.3×10^{-114} gm^3-cm^6	0.044	116(2),175,603,650(3)	-280
HfF_4(g)	70.5×10^{-114} gm^3-cm^6	0.072	131(3),139(2),603 622(3)	-410[53,34]

The statistical weights of the ground state for these species are the same as those of the corresponding hafnium chlorides.

2.3.12 HfF_4(c)

The heat of formation at 298°K (-461.4 kcal/mole) was taken from Greenberg et al.[52] Kelley[43] lists entropy (31.50 e.u.) and heat content data from which heat capacities were determined to the melting point (1200°K). The resulting function, $C_p(T) = 22.49 + 10.43 \times 10^{-3}T - 1.77 \times 10^{4}T$ cal/mole-°C, differs at 1000°K from independent data[53] by 1.2 cal/mole-°C. A heat of fusion of 18 kcal/mole was used, and a constant heat capacity of 36.2 cal/mole-°C (7.25 cal/gm-atm-°C) between 1200 and 6000°K.

2.3.13 HfOCl(g)

The heat of formation (-59 kcal/mole) at 298°K, was calculated from the heats of vaporization of Hf(c), given by Panish and Reif[54], and heats of dissociation of O_2(g) and Cl_2(g) from JANAF data[1].

Assuming a linear molecular with bond lengths for Hf-O and Hf-Cl of 1.7 A and 2.5 A, respectively, the moment of inertia is 42.18×10^{-39} gm-cm^2. The bending force constants for Hf-O_2 and Hf-Cl_2 were calculated from the wave numbers reported for HfO_2(g) and calculated for $HfCl_2$(g). Using electrostatic force theory[37], these force constants were combined to obtain the bending force constant for HfOCl(g) of 0.093×10^5 dynes/cm. This constant and

those stretching force constants calculated for HfO(g) and HfCl(g) were used in the valence force equations[15] to obtain the wave numbers 145(2), 379 and 896 cm^{-1}.

A statistical weight of 2 for the ground state was used.

2.3.14 HfOF(g)

In the same manner that thermodynamic data were estimated for HfOCl(g), the corresponding values for HfOF(g) were found to be:

Moment of inertia - 23.43×10^{-39} gm-cm^2
(linear molecule with Hf-F bond length of 2.22 A.)

Heat of formation at 298°K = -109 kcal/mole

Bending force constant (HfOF) - 0.107×10^5 dynes/cm

Wave numbers = 162(2), 630 and 898 cm^{-1}

Ground state statistical weight = 2

2.3.15 $HfOCl_2(g)$ and $HfOF_2(g)$

The simple valence force theory has its limitations, as pointed out by Herzberg[15], who cites a number of cases where theory and experiment diverge. A case of the failure of the theory was encountered in estimating wave numbers for $HfOCl_2(g)$. Estimates were being made based on the sparse experimental data available (consisting only of wave numbers for HfO(g) and the ν_3 frequencies for $HfCl_4(g)$ and $HfF_4(g)$),and on a correlation of models built from point charges according to laws of electrostatic theory[37]. As is always the case, it was desired to maintain consistency in values between the different halides, so that force constants used with these species were based on work with other species, as described earlier. In the present instance, however, the valence force theory led to complex numbers for two of the six wave numbers for $HfOCl_2(g)$. (No such problem arose with $HfOF_2(g)$; similar cases have, however, been cited by Herzberg.) It was

evident that this implied either an inadequate model in the theory (which is possible), or else substantially erroneous force constant ratios. Neither alternative seemed worth pursuing, as results are not overly sensitive to the values selected for these two wave numbers. Tentative functions were thus computed by simply neglecting the imaginary components; the results were found to be nearly identical to the corresponding results for $ZrOCl_2$ and were accepted until more experimental data become available.

Values of the effective out of plane force constants were obtained from the relation[15]

$$\left(\frac{k_\Delta}{l_1 l_2}\right)_{eff} = \frac{l_1 l_2 \left[2\,\frac{k_{\Delta 1}}{l_1^2} + \frac{k_{\Delta 2}}{l_2^2}\right]}{\left(l_1 + \frac{2\sqrt{3}}{3}\,l_2\right)^2}$$

which is derived from a force balance on the non-rotating molecule.

Calculations of moments of inertia were based on a planar symmetric molecule with equal bond angles, using the bond lengths for hafnium halides and monoxide which were described for these individual species. A symmetry number of 2 and a statistical weight of 1 for the ground state were used.

The heats of formation were calculated in the same manner described for HfOCl(g) and HfOF(g).

Results of these calculations are summarized below:

Species	ΔH^o_{f298} (kcal/mole)	$I_x I_y I_z$ ($gm^3 cm^6$)	Wave numbers (cm^{-1})
$HfOCl_2(g)$	-149	1.056×10^{-112}	88,230,307,307, 363.5,896
$HfOF_2(g)$	-248	0.14247×10^{-112}	123,269,314,619, 646,875.5

2.3.16 HfB_2(c)

The heat of formation of HfB_2(c) was taken from Paderno[55] et al., as -74.2 kcal/mole. Entropy was calculated as 9.52 e.u., based on a boron contribution of -1.75 e.u.(as described earlier for TaB_2(c), and an entropy of Hf as 10.666 e.u. The melting point was taken as 3250°C (3520°K), as given by Aronson[36]. As with other carbides and borides, the entropy of fusion was set at 2.5 e.u./gram-atom, giving a heat of fusion of 26.4 kcal/mol.

Margrave's[34] enthalpy data were again compared to additivities in the range 298-1200°K, and an empirical constant relating measured values to additivities used to extend the data to 2000°K:

T, °K	Additivities	Mezaki	Ratio
500	2.804	3.633	.774
700	6.100	6.353	.961
900	9.715	9.988	.972
1100	13.574	13.938	.972
1200	15.580	16.030	.972
2000	32.931		

The assigned value at 2000° was .972 x 32.931 or 32.009. Using these data the heat capacity equation was derived:

$$C_p = 20.807 - .256 \times 10^{-3}T - 1.0164 \times 10^{6}T^{-2}$$

This equation shows a maximum at 1990°K; above 2000° the heat capacity was assumed to increase linearly to the melting point, at and above which value a heat capacity of 21 cal/mole-°K was used.

2.3.17 HfC(c)

The heat of formation was taken from Kelley[43], who estimates ΔH^{o}_{f298} as -44.7 kcal/mole. Kelley[43] assumes the entropy at 298° to be the same as the entropy of the metal, which he places at 10.91 e.u. The value for standard entropy of Hf selected for our purposes, from the AVCO report[4], is 10.666 e.u.; we note, however, that for TaC the selected entropy is 1.159 units less than the sum of graphite plus tantalum or 0.20 units greater than the metal. With this same approach, a value of 10.866 would be placed on HfC. A value of 10.9 was used.

The melting point was determined in 1930 by Agte and Alterthum[56] as 3890°C; no more recent value has been found. The value of 4160°K was used. Following previous procedure, the entropy of fusion was set at 5.0 e.u., and the heat of fusion at 20.8 kcal/mole. Kelley[43] gives estimated heat content data at 2000°K. Southern Research Institute reports experimental data to approximately 3000°K, with heat capacities peaking at 13.7 cal/mol-°K. Kelley's heat content estimates were fitted to points at 298.15, 700, 1200, and 2000°K. The equation resulting was

$$C_p = 8.290 + .00316T - 7540T^{-2}$$

This equation was used to a temperature of 2000°, above which temperature the heat capacity was assumed constant at 14.61 cal/mol-°K.

2.3.18 HfN(c)

Humphrey[57] gives the heat of formation as -88.24 kcal/mole. Entropy at 298°K was taken from Kelley[43], who estimates S^{o}_{298} at the same value as the metal, or 10.91 e.u. Correction to the value of 10.666 e.u. for the metal, as used here, did not seem merited. Humphrey[57] estimated 13.1 e.u. The melting point was taken from Brewer et al,[29] who gave the melting point at 3580°K. The entropy of fusion and heat of fusion were taken as 5.0 e.u./mol and 17.9 kcal/mole. Kelley[34] gives heat contents to 2000°K. Neel[27] gives data to 4750°F(2900°K); their data however show an

approximate 30 percent decrease in heat capacity between a peak value of 15.0 at 1500°F (1100°K) and the value at 4500°F (2760°K) of 10.2. At about 1100°K, Kelley estimates (as computed from his heat content values) the heat capacity to be about 12.6 increasing to 14.2 at about 2000°K. Kelley's data seem more reasonable, and were fitted at 298.15, 700, 1200 and 2000°K as before. The equation resulting was

$$C_p = 9.889 + .0219T - 6.634 \times 10^3 T^{-2}$$

which was used to 2000°. Above this temperature the heat capacity was assumed to be constant at 14.27 cal/mol-°K.

SECTION 3

TABLES OF THERMODYNAMIC PROPERTIES

3.1 INTRODUCTION

The computed thermodynamic properties are presented in the following pages. Properties are computed at intervals of 100°Kelvin. The temperature base of 298.15° Kelvin is abbreviated in the table headings as 298. The heading H^T_{298} refers to the usual term, $(H^\circ_T - H^\circ_{298})$. The term ΔH°_{f298} refers to the heat liberated in the process of forming the specified species from the elements in their standard states at 298.15°K. The heading S refers to the absolute entropy.

3.2 TANTALUM SPECIES

THERMODYNAMIC FUNCTIONS OF Te(g)

ΔH°_{f298} = 186.8 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	44.243	44.243	4.985	0.000
300	44.243	44.274	4.986	0.009
400	44.440	45.719	5.081	0.512
500	44.815	46.872	5.278	1.029
600	45.241	47.857	5.541	1.570
700	45.679	48.733	5.827	2.138
800	46.111	49.530	6.110	2.735
900	46.532	50.265	6.376	3.359
1000	46.940	50.949	6.621	4.009
1100	47.334	51.591	6.844	4.683
1200	47.714	52.195	7.044	5.377
1300	48.081	52.766	7.221	6.091
1400	48.435	53.307	7.377	6.821
1500	48.777	53.821	7.514	7.565
1600	49.108	54.310	7.633	8.323
1700	49.428	54.776	7.739	9.092
1800	49.737	55.221	7.832	9.870
1900	50.037	55.647	7.916	10.658
2000	40.328	56.055	7.993	11.453
2100	50.610	56.446	8.064	12.256
2200	50.884	56.823	8.132	13.066
2300	51.150	57.186	8.196	13.882
2400	51.409	57.536	8.258	14.705
2500	51.661	57.874	8.319	15.534
2600	51.906	58.202	8.378	16.369
2700	52.145	58.519	8.437	17.210
2800	52.378	48.827	8.495	18.056
2900	52.606	49.126	8.552	18.909
3000	52.828	59.417	8.610	19.767
3100	53.045	59.700	8.667	20.631
3200	53.258	59.976	8.725	21.500
3300	53.465	60.246	8.783	22.376
3400	53.669	60.509	8.841	23.257
3500	53.868	60.766	8.900	24.144
3600	54.063	61.018	8.959	25.037
3700	54.254	61.264	9.019	25.936
3800	54.442	61.505	9.079	26.841
3900	54.626	61.742	9.139	27.752
4000	54.807	61.974	9.200	28.668
4100	54.984	62.202	9.261	29.592
4200	55.159	62.426	9.322	30.521
4300	55.330	62.646	9.383	31.456
4400	55.499	62.862	9.444	32.397
4500	55.665	63.075	9.504	33.345
4600	55.829	63.285	9.564	34.298
4700	55.989	63.491	9.623	35.258
4800	56.148	63.694	9.680	36.223
4900	56.304	63.894	9.737	37.194
5000	56.458	64.092	9.792	38.170
5100	56.609	64.286	9.846	39.152
5200	56.759	64.478	9.897	40.139
5300	56.906	64.667	9.947	41.131
5400	57.052	64.853	9.995	42.128
5500	57.195	65.037	10.040	43.130
5600	57.337	62.218	10.083	44.136
5700	57.477	65.397	10.124	45.147
5800	57.615	65.573	10.161	46.161
5900	57.751	65.747	10.197	47.179
6000	57.886	65.919	10.229	48.200

THERMODYNAMIC FUNCTIONS OF Ta(c)

$\Delta H^{\circ}_{f298} = 0$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	9.900	9.900	6.028	0
300.00	9.900	9.937	6.029	.011
400.00	10.137	11.678	6.072	.616
500.00	10.586	13.037	6.115	1.226
600.00	11.091	14.156	6.158	1.839
700.00	11.598	15.108	6.201	2.457
800.00	12.090	15.939	6.244	3.079
900.00	12.559	16.677	6.287	3.706
1000.00	13.005	17.342	6.330	4.337
1100.00	13.427	17.947	6.373	4.972
1200.00	13.827	18.503	6.416	5.611
1300.00	14.207	19.019	6.459	6.255
1400.00	14.568	19.499	6.502	6.903
1500.00	14.912	19.949	6.545	7.556
1600.00	15.240	20.373	6.588	8.212
1700.00	15.554	20.773	6.631	8.873
1800.00	15.855	21.154	6.674	9.538
1900.00	16.143	21.516	6.717	10.208
2000.00	16.420	21.861	6.760	10.882
2100.00	16.687	22.192	6.803	11.560
2200.00	16.945	22.510	6.846	12.242
2300.00	17.194	22.815	6.889	12.929
2400.00	17.434	23.109	6.932	13.620
2500.00	17.667	23.393	6.975	14.316
2600.00	17.892	23.667	7.018	15.015
2700.00	18.111	23.933	7.061	15.719
2800.00	18.324	24.190	7.104	16.427
2900.00	18.530	24.441	7.147	17.140
3000.00	18.731	24.684	7.190	17.857
3100.00	18.927	24.920	7.233	18.578
3200.00	19.118	25.150	7.276	19.303
3300.00	19.325	27.675	8.000	27.554
3400.00	19.574	27.914	8.000	28.354
3500.00	19.816	28.145	8.000	29.154
3600.00	20.050	28.371	8.000	29.954
3700.00	20.278	28.590	8.000	30.754
3800.00	20.500	28.803	8.000	31.554
3900.00	20.715	29.011	8.000	32.354
4000.00	20.925	29.214	8.000	33.154
4100.00	21.130	29.411	8.000	33.954
4200.00	21.329	29.604	8.000	34.754
4300.00	21.524	29.792	8.000	35.554
4400.00	21.714	29.976	8.000	36.354
4500.00	21.900	30.156	8.000	37.154
4600.00	22.081	30.332	8.000	37.954
4700.00	22.258	30.504	8.000	38.754
4800.00	22.432	30.672	8.000	39.554
4900.00	22.602	30.837	8.000	40.354
5000.00	22.768	30.999	8.000	41.154
5100.00	22.931	31.157	8.000	41.954
5200.00	23.091	31.313	8.000	42.754
5300.00	23.247	31.465	8.000	43.554
5400.00	23.401	31.615	8.000	44.354
5500.00	23.552	31.761	8.000	45.154
5600.00	23.699	31.905	8.000	45.954
5700.00	23.845	32.047	8.000	46.754
5800.00	23.987	32.186	8.000	47.554
5900.00	24.127	32.323	8.000	48.354
6000.00	24.265	32.457	8.000	49.154

THERMODYNAMIC FUNCTIONS OF TaO(g)

ΔH°_{f298} = 50 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole
298.15	57.950	57.950	7.421	C
300.00	57.950	57.996	7.428	.014
400.00	58.246	60.186	7.803	.776
500.00	58.817	61.960	8.090	1.571
600.00	59.469	63.454	8.294	2.391
700.00	60.132	64.744	8.437	3.228
800.00	60.781	65.877	8.540	4.077
900.00	61.404	66.888	8.616	4.935
1000.00	61.999	67.799	8.673	5.800
1100.00	62.564	68.627	8.716	6.669
1200.00	63.102	69.387	8.750	7.543
1300.00	63.613	70.089	8.777	8.419
1400.00	64.099	70.740	8.799	9.298
1500.00	64.562	71.348	8.817	10.179
1600.00	65.004	71.917	8.831	11.061
1700.00	65.427	72.453	8.844	11.945
1800.00	65.831	72.959	8.854	12.830
1900.00	66.219	73.438	8.863	13.716
2000.00	66.591	73.893	8.871	14.603
2100.00	66.949	74.326	8.877	15.490
2200.00	67.294	74.739	8.883	16.378
2300.00	67.627	75.134	8.888	17.266
2400.00	67.947	75.512	8.892	18.155
2500.00	68.257	75.875	8.896	19.045
2600.00	68.557	76.224	8.899	19.935
2700.00	68.847	76.560	8.903	20.825
2800.00	69.128	76.884	8.905	21.715
2900.00	69.401	77.196	8.908	22.606
3000.00	69.666	77.498	8.910	23.497
3100.00	69.924	77.791	8.912	24.388
3200.00	70.174	78.074	8.914	25.279
3300.00	70.417	78.348	8.916	26.171
3400.00	70.655	78.614	8.917	27.062
3500.00	70.886	78.873	8.919	27.954
3600.00	71.111	79.124	8.920	28.846
3700.00	71.331	79.368	8.921	29.738
3800.00	71.546	79.606	8.922	30.630
3900.00	71.755	79.838	8.923	31.522
4000.00	71.960	80.064	8.924	32.415
4100.00	72.160	80.284	8.925	33.307
4200.00	72.356	80.499	8.926	34.200
4300.00	72.548	80.709	8.927	35.092
4400.00	72.736	80.915	8.927	35.985
4500.00	72.920	81.115	8.928	36.878
4600.00	73.100	81.311	8.929	37.771
4700.00	73.277	81.503	8.929	38.664
4800.00	73.450	81.691	8.930	39.556
4900.00	73.621	81.876	8.930	40.449
5000.00	73.787	82.056	8.931	41.343
5100.00	73.951	82.233	8.931	42.236
5200.00	74.112	82.406	8.932	43.129
5300.00	74.270	82.576	8.932	44.022
5400.00	74.426	82.743	8.932	44.915
5500.00	74.578	82.907	8.933	45.808
5600.00	74.729	83.068	8.933	46.702
5700.00	74.876	83.226	8.933	47.595
5800.00	75.022	83.382	8.934	48.488
5900.00	75.165	83.534	8.934	49.382
6000.00	75.305	83.685	8.934	50.275

THERMODYNAMIC FUNCTIONS OF TeO_2(s)

$\Delta H^{\circ}_{f298} = -41$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	62.053	62.053	11.506	0
300.00	62.053	62.124	11.526	.021
400.00	62.517	65.575	12.459	1.223
500.00	63.422	68.429	13.110	2.504
600.00	64.464	70.861	13.553	3.838
700.00	65.533	72.975	13.859	5.210
800.00	66.582	74.841	14.076	6.607
900.00	67.594	76.508	14.234	8.023
1000.00	68.562	78.014	14.352	9.453
1100.00	69.484	79.386	14.442	10.892
1200.00	70.363	80.646	14.512	12.340
1300.00	71.199	81.810	14.567	13.794
1400.00	71.996	82.891	14.612	15.253
1500.00	72.756	83.900	14.648	16.716
1600.00	73.483	84.847	14.678	18.183
1700.00	74.178	85.737	14.703	19.652
1800.00	74.845	86.578	14.724	21.123
1900.00	75.482	87.375	14.742	22.596
2000.00	76.096	88.132	14.758	24.071
2100.00	76.686	88.852	14.771	25.548
2200.00	77.255	89.539	14.783	27.026
2300.00	77.804	90.197	14.793	28.504
2400.00	78.333	90.827	14.802	29.984
2500.00	78.845	91.431	14.810	31.465
2600.00	79.340	92.012	14.817	32.946
2700.00	79.820	92.571	14.823	34.428
2800.00	80.285	93.110	14.829	35.911
2900.00	80.736	93.631	14.834	37.394
3000.00	81.175	94.134	14.838	38.877
3100.00	81.601	94.620	14.842	40.361
3200.00	82.015	95.092	14.846	41.846
3300.00	82.418	95.549	14.850	43.331
3400.00	82.811	95.992	14.853	44.816
3500.00	83.194	96.423	14.856	46.301
3600.00	83.567	96.841	14.858	47.787
3700.00	83.931	97.248	14.861	49.273
3800.00	84.287	97.645	14.863	50.759
3900.00	84.634	98.031	14.865	52.245
4000.00	84.974	98.407	14.867	53.732
4100.00	85.306	98.774	14.869	55.219
4200.00	85.631	99.132	14.870	56.706
4300.00	85.949	99.482	14.872	58.193
4400.00	86.261	99.824	14.873	59.680
4500.00	86.566	100.159	14.875	61.168
4600.00	86.865	100.485	14.876	62.655
4700.00	87.158	100.805	14.877	64.143
4800.00	87.446	101.119	14.878	65.631
4900.00	87.728	101.425	14.879	67.118
5000.00	88.005	101.726	14.880	68.606
5100.00	88.277	102.021	14.881	70.094
5200.00	88.544	102.310	14.882	71.583
5300.00	88.806	102.593	14.883	73.071
5400.00	89.064	102.871	14.884	74.559
5500.00	89.318	103.144	14.884	76.048
5600.00	89.567	103.413	14.885	77.536
5700.00	89.812	103.676	14.886	79.025
5800.00	90.053	103.935	14.886	80.513
5900.00	90.291	104.190	14.887	82.002
6000.00	90.525	104.440	14.887	83.491

THERMODYNAMIC FUNCTION OF Ta_2O_5(c)

ΔH^{o}_{f298} = -488.8 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	34.200	34.200	32.296	0
300.00	34.201	34.400	32.390	.060
400.00	35.521	44.261	35.924	3.496
500.00	38.117	52.508	37.912	7.195
600.00	41.117	59.548	39.292	11.059
700.00	44.198	65.649	40.384	15.044
800.00	47.231	71.144	41.323	19.131
900.00	50.166	76.061	42.173	23.306
1000.00	52.983	80.546	42.968	27.563
1100.00	55.679	84.677	43.727	31.898
1200.00	58.257	88.514	44.461	36.308
1300.00	60.724	92.101	45.178	40.790
1400.00	63.087	95.475	45.882	45.343
1500.00	65.353	98.664	46.577	49.966
1600.00	67.531	101.692	47.265	54.658
1700.00	69.626	104.578	47.947	59.419
1800.00	71.645	107.338	48.625	64.247
1900.00	73.593	109.985	49.300	69.144
2000.00	75.477	112.531	49.972	74.107
2100.00	77.300	114.985	50.642	79.138
2200.00	79.450	134.268	56.000	120.598
2300.00	81.888	136.757	56.000	126.198
2400.00	84.225	139.141	56.000	131.798
2500.00	86.467	141.427	56.000	137.398
2600.00	88.624	143.623	56.000	142.998
2700.00	90.700	145.736	56.000	148.598
2800.00	92.702	147.773	56.000	154.198
2900.00	94.635	149.738	56.000	159.798
3000.00	96.504	151.637	56.000	165.398
3100.00	98.312	153.473	56.000	170.998
3200.00	100.064	155.251	56.000	176.598
3300.00	101.762	156.974	56.000	182.198
3400.00	103.411	158.646	56.000	187.798
3500.00	105.012	160.269	56.000	193.398
3600.00	106.569	161.847	56.000	198.998
3700.00	108.084	163.381	56.000	204.598
3800.00	109.559	164.874	56.000	210.198
3900.00	110.996	166.329	56.000	215.798
4000.00	112.397	167.747	56.000	221.398
4100.00	113.764	169.130	56.000	226.998
4200.00	115.098	170.479	56.000	232.598
4300.00	116.402	171.797	56.000	238.198
4400.00	117.675	173.084	56.000	243.798
4500.00	118.921	174.343	56.000	249.398
4600.00	120.139	175.573	56.000	254.998
4700.00	121.331	176.778	56.000	260.598
4800.00	122.499	177.957	56.000	266.198
4900.00	123.642	179.111	56.000	271.798
5000.00	124.763	180.243	56.000	277.398
5100.00	125.862	181.352	56.000	282.998
5200.00	126.939	182.439	56.000	288.598
5300.00	127.997	183.506	56.000	294.198
5400.00	129.034	184.553	56.000	299.798
5500.00	130.053	185.580	56.000	305.398
5600.00	131.054	186.589	56.000	310.998
5700.00	132.037	187.580	56.000	316.598
5800.00	133.003	188.554	56.000	322.198
5900.00	133.953	189.512	56.000	327.798
6000.00	134.886	190.453	56.000	333.398

THERMODYNAMIC FUNCTIONS OF TaF(g)

ΔH°_{f298} = 60.7 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	57.618	57.618	8.106	C
300.00	57.618	57.668	8.113	.015
400.00	57.940	60.047	8.412	.843
500.00	58.557	61.944	8.581	1.693
600.00	59.257	63.518	8.682	2.557
700.00	59.964	64.861	8.747	3.428
800.00	60.651	66.032	8.791	4.305
900.00	61.307	67.070	8.821	5.186
1000.00	61.931	68.000	8.844	6.069
1100.00	62.522	68.844	8.860	6.955
1200.00	63.081	69.615	8.873	7.841
1300.00	63.611	70.326	8.883	8.729
1400.00	64.115	70.985	8.891	9.618
1500.00	64.593	71.598	8.898	10.507
1600.00	65.049	72.173	8.903	11.397
1700.00	65.484	72.713	8.908	12.288
1800.00	65.900	73.222	8.911	13.179
1900.00	66.298	73.704	8.914	14.070
2000.00	66.680	74.161	8.917	14.962
2100.00	67.047	74.596	8.919	15.854
2200.00	67.400	75.011	8.921	16.746
2300.00	67.739	75.408	8.923	17.638
2400.00	68.067	75.788	8.925	18.530
2500.00	68.383	76.152	8.926	19.423
2600.00	68.688	76.502	8.927	20.315
2700.00	68.984	76.839	8.928	21.208
2800.00	69.270	77.164	8.929	22.101
2900.00	69.548	77.477	8.930	22.994
3000.00	69.817	77.780	8.931	23.887
3100.00	70.079	78.073	8.932	24.780
3200.00	70.333	78.356	8.932	25.674
3300.00	70.581	78.631	8.933	26.567
3400.00	70.821	78.898	8.934	27.460
3500.00	71.056	79.157	8.934	28.354
3600.00	71.284	79.409	8.935	29.247
3700.00	71.507	79.653	8.935	30.141
3800.00	71.725	79.892	8.935	31.034
3900.00	71.937	80.124	8.936	31.928
4000.00	72.145	80.350	8.936	32.821
4100.00	72.347	80.571	8.936	33.715
4200.00	72.544	80.786	8.937	34.608
4300.00	72.740	80.996	8.937	35.502
4400.00	72.930	81.202	8.937	36.396
4500.00	73.116	81.403	8.937	37.290
4600.00	73.298	81.599	8.938	38.183
4700.00	73.477	81.791	8.938	39.077
4800.00	73.652	81.979	8.938	39.971
4900.00	73.824	82.164	8.938	40.865
5000.00	73.993	82.344	8.938	41.758
5100.00	74.158	82.521	8.938	42.652
5200.00	74.321	82.695	8.939	43.546
5300.00	74.480	82.865	8.939	44.440
5400.00	74.637	83.032	8.939	45.334
5500.00	74.791	83.196	8.939	46.228
5600.00	74.943	83.357	8.939	47.122
5700.00	75.092	83.515	8.939	48.016
5800.00	75.238	83.671	8.939	48.910
5900.00	75.382	83.824	8.939	49.804
6000.00	75.524	83.974	8.940	50.698

THERMODYNAMIC FUNCTIONS OF $TaF_2(g)$

ΔH°_{f298} = -65.5 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	63.433	63.433	12.773	0
300.00	63.434	63.513	12.793	.024
400.00	63.946	67.313	13.580	1.347
500.00	64.938	70.394	14.010	2.728
600.00	66.068	72.972	14.264	4.143
700.00	67.216	75.184	14.425	5.578
800.00	68.335	77.118	14.533	7.026
900.00	69.408	78.834	14.608	8.483
1000.00	70.429	80.376	14.663	9.947
1100.00	71.396	81.776	14.704	11.415
1200.00	72.317	83.056	14.735	12.887
1300.00	73.185	84.237	14.760	14.362
1400.00	74.018	85.331	14.779	15.839
1500.00	74.806	86.352	14.795	17.318
1600.00	75.558	87.307	14.808	18.799
1700.00	76.276	88.205	14.819	20.279
1800.00	76.962	89.052	14.828	21.762
1900.00	77.620	89.854	14.836	23.245
2000.00	78.251	90.615	14.843	24.729
2100.00	78.857	91.340	14.848	26.214
2200.00	79.440	92.031	14.853	27.699
2300.00	80.002	92.691	14.857	29.184
2400.00	80.544	93.323	14.861	30.670
2500.00	81.067	93.930	14.865	32.156
2600.00	81.573	94.513	14.868	33.643
2700.00	82.063	95.074	14.870	35.130
2800.00	82.538	95.615	14.873	36.617
2900.00	82.998	96.137	14.875	38.104
3000.00	83.444	96.641	14.877	39.592
3100.00	83.878	97.129	14.878	41.080
3200.00	84.299	97.602	14.880	42.568
3300.00	84.709	98.059	14.881	44.056
3400.00	85.108	98.504	14.883	45.544
3500.00	85.497	98.935	14.884	47.032
3600.00	85.876	99.354	14.885	48.521
3700.00	86.246	99.762	14.886	50.009
3800.00	86.607	100.159	14.887	51.498
3900.00	86.960	100.546	14.888	52.987
4000.00	87.304	100.923	14.889	54.475
4100.00	87.641	101.291	14.889	55.964
4200.00	87.970	101.649	14.890	57.453
4300.00	88.292	102.000	14.891	58.942
4400.00	88.608	102.342	14.891	60.431
4500.00	88.917	102.677	14.892	61.920
4600.00	89.219	103.004	14.892	63.410
4700.00	89.516	103.324	14.893	64.899
4800.00	89.807	103.638	14.893	66.388
4900.00	90.092	103.945	14.894	67.878
5000.00	90.372	104.246	14.894	69.367
5100.00	90.647	104.541	14.894	70.856
5200.00	90.917	104.830	14.895	72.346
5300.00	91.183	105.114	14.895	73.835
5400.00	91.443	105.392	14.896	75.325
5500.00	91.699	105.665	14.896	76.814
5600.00	91.951	105.934	14.896	78.304
5700.00	92.199	106.198	14.896	79.794
5800.00	92.442	106.457	14.897	81.283
5900.00	92.682	106.711	14.897	82.773
6000.00	92.918	106.962	14.897	84.263

THERMODYNAMIC FUNCTIONS OF TaF_3(g)

ΔH°_{f298} = -192 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	73.327	73.327	16.728	0
300.00	73.328	73.431	16.757	.031
400.00	74.001	78.428	17.917	1.771
500.00	75.306	82.501	18.551	3.597
600.00	76.798	85.919	18.926	5.473
700.00	78.316	88.855	19.164	7.378
800.00	79.767	91.426	19.323	9.303
900.00	81.218	93.708	19.435	11.241
1000.00	82.572	95.760	19.516	13.189
1100.00	83.857	97.623	19.576	15.143
1200.00	85.076	99.329	19.623	17.103
1300.00	86.233	100.901	19.659	19.068
1400.00	87.334	102.359	19.688	21.035
1500.00	88.381	103.718	19.711	23.005
1600.00	89.380	104.991	19.731	24.977
1700.00	90.334	106.187	19.747	26.951
1800.00	91.246	107.316	19.760	28.926
1900.00	92.120	108.385	19.771	30.903
2000.00	92.959	109.399	19.781	32.881
2100.00	93.765	110.365	19.790	34.859
2200.00	94.541	111.286	19.797	36.838
2300.00	95.288	112.166	19.803	38.818
2400.00	96.009	113.009	19.809	40.799
2500.00	96.705	113.817	19.814	42.780
2600.00	97.378	114.595	19.818	44.762
2700.00	98.030	115.343	19.822	46.744
2800.00	98.661	116.063	19.825	48.726
2900.00	99.273	116.759	19.829	50.709
3000.00	99.868	117.431	19.831	52.692
3100.00	100.445	118.082	19.834	54.675
3200.00	101.006	118.712	19.836	56.659
3300.00	101.552	119.322	19.838	58.642
3400.00	102.083	119.914	19.840	60.626
3500.00	102.601	120.489	19.842	62.610
3600.00	103.105	121.048	19.844	64.595
3700.00	103.598	121.592	19.845	66.579
3800.00	104.078	122.121	19.847	68.564
3900.00	104.547	122.637	19.848	70.549
4000.00	105.006	123.139	19.849	72.533
4100.00	105.454	123.629	19.850	74.518
4200.00	105.893	124.108	19.851	76.503
4300.00	106.322	124.575	19.852	78.489
4400.00	106.742	125.031	19.853	80.474
4500.00	107.153	125.478	19.854	82.459
4600.00	107.556	125.914	19.855	84.445
4700.00	107.952	126.341	19.855	86.430
4800.00	108.339	126.759	19.856	88.416
4900.00	108.719	127.168	19.857	90.401
5000.00	109.092	127.570	19.857	92.387
5100.00	109.458	127.963	19.858	94.373
5200.00	109.818	128.348	19.858	96.359
5300.00	110.171	128.727	19.859	98.345
5400.00	110.518	129.098	19.859	100.330
5500.00	110.859	129.462	19.860	102.316
5600.00	111.195	129.820	19.860	104.302
5700.00	111.524	130.172	19.861	106.289
5800.00	111.849	130.517	19.861	108.275
5900.00	112.168	130.857	19.861	110.261
6000.00	112.483	131.190	19.862	112.247

THERMODYNAMIC FUNCTIONS OF $TaF_4(g)$

ΔH°_{f298} = -318 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	76.560	76.560	21.218	C
300.00	76.561	76.691	21.262	.039
400.00	77.418	83.070	22.980	2.261
500.00	79.095	88.308	23.911	4.610
600.00	81.003	92.720	24.459	7.030
700.00	82.954	96.518	24.805	9.495
800.00	84.862	99.846	25.037	11.988
900.00	86.694	102.805	25.199	14.500
1000.00	88.441	105.467	25.317	17.026
1100.00	90.100	107.884	25.405	19.562
1200.00	91.675	110.097	25.472	22.106
1300.00	93.172	112.138	25.525	24.656
1400.00	94.595	114.031	25.567	27.211
1500.00	95.950	115.797	25.601	29.769
1600.00	97.243	117.450	25.629	32.331
1700.00	98.478	119.004	25.652	34.895
1800.00	99.659	120.471	25.671	37.461
1900.00	100.791	121.959	25.688	40.029
2000.00	101.878	123.177	25.702	42.598
2100.00	102.922	124.437	25.714	45.169
2200.00	103.927	125.628	25.725	47.741
2300.00	104.896	126.772	25.734	50.314
2400.00	105.830	127.867	25.742	52.888
2500.00	106.733	128.918	25.749	55.462
2600.00	107.606	129.928	25.755	58.038
2700.00	108.451	130.900	25.761	60.614
2800.00	109.269	131.837	25.766	63.190
2900.00	110.063	132.741	25.771	65.767
3000.00	110.834	133.615	25.775	68.344
3100.00	111.582	134.460	25.779	70.922
3200.00	112.310	135.279	25.782	73.500
3300.00	113.018	136.072	25.785	76.078
3400.00	113.708	136.842	25.788	78.657
3500.00	114.379	137.590	25.790	81.236
3600.00	115.034	138.316	25.793	83.815
3700.00	115.673	139.023	25.795	86.394
3800.00	116.297	139.711	25.797	88.974
3900.00	116.906	140.381	25.799	91.554
4000.00	117.501	141.034	25.801	94.134
4100.00	118.083	141.671	25.802	96.714
4200.00	118.652	142.293	25.804	99.294
4300.00	119.208	142.900	25.805	101.874
4400.00	119.754	143.493	25.806	104.455
4500.00	120.288	144.073	25.807	107.036
4600.00	120.811	144.641	25.809	109.616
4700.00	121.324	145.196	25.810	112.197
4800.00	121.827	145.739	25.811	114.778
4900.00	122.320	146.271	25.812	117.360
5000.00	122.805	146.793	25.812	119.941
5100.00	123.280	147.304	25.813	122.522
5200.00	123.747	147.805	25.814	125.103
5300.00	124.205	148.297	25.815	127.685
5400.00	124.656	148.779	25.815	130.266
5500.00	125.099	149.253	25.816	132.848
5600.00	125.534	149.718	25.817	135.430
5700.00	125.963	150.175	25.817	138.011
5800.00	126.384	150.624	25.818	140.593
5900.00	126.799	151.066	25.818	143.175
6000.00	127.207	151.499	25.819	145.757

THERMODYNAMIC FUNCTIONS OF $TaF_5(g)$

ΔH°_{f298} = -444 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	81.000	81.000	25.327	0
300.00	81.000	81.157	25.397	.047
400.00	82.033	88.853	27.872	2.728
500.00	84.052	95.210	29.023	5.579
600.00	86.370	100.562	29.653	8.516
700.00	88.734	105.164	30.036	11.502
800.00	91.045	109.193	30.289	14.519
900.00	93.284	112.771	30.466	17.557
1000.00	95.378	115.988	30.595	20.610
1100.00	97.386	118.909	30.693	23.675
1200.00	99.293	121.583	30.770	26.748
1300.00	101.104	124.048	30.832	29.828
1400.00	102.825	126.335	30.884	32.914
1500.00	104.464	128.467	30.927	36.005
1600.00	106.028	130.465	30.965	39.099
1700.00	107.521	132.343	30.997	42.198
1800.00	108.950	134.116	31.027	45.299
1900.00	110.319	135.794	31.053	48.403
2000.00	111.633	137.387	31.077	51.509
2100.00	112.895	138.904	31.099	54.618
2200.00	114.111	140.351	31.119	57.729
2300.00	115.282	141.735	31.138	60.842
2400.00	116.412	143.060	31.156	63.956
2500.00	117.504	144.333	31.173	67.073
2600.00	118.559	145.556	31.189	70.191
2700.00	119.581	146.733	31.205	73.311
2800.00	120.571	147.868	31.220	76.432
2900.00	121.531	148.964	31.235	79.555
3000.00	122.463	150.023	31.249	82.679
3100.00	123.369	151.048	31.263	85.805
3200.00	124.250	152.041	31.276	88.931
3300.00	125.106	153.003	31.289	92.060
3400.00	125.941	153.938	31.302	95.189
3500.00	126.754	154.845	31.315	98.320
3600.00	127.546	155.727	31.327	101.452
3700.00	128.320	156.586	31.339	104.586
3800.00	129.075	157.422	31.351	107.720
3900.00	129.812	158.236	31.363	110.856
4000.00	130.532	159.031	31.375	113.993
4100.00	131.237	159.806	31.387	117.131
4200.00	131.926	160.562	31.398	120.270
4300.00	132.601	161.301	31.410	123.410
4400.00	133.261	162.023	31.421	126.552
4500.00	133.908	162.729	31.433	129.695
4600.00	134.542	163.420	31.444	132.839
4700.00	135.164	164.097	31.455	135.983
4800.00	135.774	164.759	31.466	139.130
4900.00	136.372	165.408	31.477	142.277
5000.00	136.959	166.044	31.488	145.425
5100.00	137.536	166.668	31.499	148.574
5200.00	138.102	167.279	31.510	151.725
5300.00	138.658	167.880	31.521	154.876
5400.00	139.204	168.469	31.532	158.029
5500.00	139.742	169.048	31.543	161.183
5600.00	140.270	169.616	31.553	164.338
5700.00	140.790	170.175	31.564	167.493
5800.00	141.301	170.724	31.575	170.650
5900.00	141.805	171.264	31.585	173.808
6000.00	142.300	171.795	31.596	176.967

THERMODYNAMIC FUNCTION OF TaCL(g)

ΔH°_{f298} = 110 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	60.276	60.276	8.561	0
300.00	60.276	60.329	8.565	.016
400.00	60.614	62.816	8.718	.881
500.00	61.257	64.771	8.795	1.757
600.00	61.981	66.379	8.839	2.639
700.00	62.709	67.743	8.866	3.524
800.00	63.414	68.929	8.883	4.412
900.00	64.086	69.976	8.896	5.301
1000.00	64.722	70.913	8.904	6.191
1100.00	65.324	71.762	8.911	7.082
1200.00	65.894	72.538	8.916	7.973
1300.00	66.433	73.252	8.920	8.865
1400.00	66.944	73.913	8.923	9.757
1500.00	67.429	74.528	8.925	10.649
1600.00	67.891	75.105	8.927	11.542
1700.00	68.331	75.646	8.929	12.435
1800.00	68.752	76.156	8.931	13.328
1900.00	69.154	76.639	8.932	14.221
2000.00	69.540	77.097	8.933	15.114
2100.00	69.911	77.533	8.934	16.007
2200.00	70.267	77.949	8.934	16.901
2300.00	70.609	78.346	8.935	17.794
2400.00	70.940	78.726	8.936	18.688
2500.00	71.258	79.091	8.936	19.581
2600.00	71.566	79.441	8.937	20.475
2700.00	71.864	79.779	8.937	21.369
2800.00	72.153	80.104	8.937	22.263
2900.00	72.432	80.417	8.938	23.156
3000.00	72.704	80.720	8.938	24.050
3100.00	72.967	81.014	8.938	24.944
3200.00	73.223	81.297	8.939	25.838
3300.00	73.472	81.572	8.939	26.732
3400.00	73.714	81.839	8.939	27.626
3500.00	73.950	82.098	8.939	28.519
3600.00	74.180	82.350	8.939	29.413
3700.00	74.404	82.595	8.940	30.307
3800.00	74.623	82.833	8.940	31.201
3900.00	74.836	83.066	8.940	32.095
4000.00	75.045	83.292	8.940	32.989
4100.00	75.249	83.513	8.940	33.883
4200.00	75.448	83.728	8.940	34.777
4300.00	75.643	83.939	8.940	35.671
4400.00	75.834	84.144	8.940	36.565
4500.00	76.021	84.345	8.941	37.459
4600.00	76.204	84.542	8.941	38.353
4700.00	76.383	84.734	8.941	39.248
4800.00	76.559	84.922	8.941	40.142
4900.00	76.732	85.106	8.941	41.036
5000.00	76.901	85.287	8.941	41.930
5100.00	77.067	85.464	8.941	42.824
5200.00	77.230	85.638	8.941	43.718
5300.00	77.391	85.808	8.941	44.612
5400.00	77.548	85.975	8.941	45.506
5500.00	77.703	86.139	8.941	46.400
5600.00	77.855	86.300	8.941	47.294
5700.00	78.004	86.459	8.941	48.189
5800.00	78.152	86.614	8.941	49.083
5900.00	78.296	86.767	8.941	49.977
6000.00	78.439	86.917	8.941	50.871

THERMODYNAMIC FUNCTION OF $ZnCl_2(s)$

ΔH°_{f298} = 33 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	70.104	70.104	14.068	0
300.00	70.104	70.191	14.057	.026
400.00	70.661	74.289	14.404	1.451
500.00	71.721	77.523	14.577	2.931
600.00	72.917	80.190	14.674	4.364
700.00	74.122	82.457	14.733	5.835
800.00	75.290	84.427	14.773	7.310
900.00	76.404	86.169	14.800	8.789
1000.00	77.459	87.729	14.820	10.270
1100.00	78.458	89.142	14.834	11.753
1200.00	79.403	90.434	14.845	13.237
1300.00	80.298	91.622	14.854	14.722
1400.00	81.147	92.723	14.861	16.207
1500.00	81.953	93.749	14.866	17.694
1600.00	82.721	94.708	14.871	19.180
1700.00	83.453	95.610	14.875	20.668
1800.00	84.152	96.460	14.878	22.155
1900.00	84.821	97.265	14.880	23.643
2000.00	85.462	98.028	14.883	25.131
2100.00	86.078	98.754	14.885	26.620
2200.00	86.670	99.447	14.886	28.108
2300.00	87.240	100.109	14.888	29.597
2400.00	87.790	100.742	14.889	31.086
2500.00	88.320	101.350	14.890	32.575
2600.00	88.832	101.934	14.891	34.064
2700.00	89.328	102.496	14.892	35.553
2800.00	89.808	103.038	14.893	37.042
2900.00	90.273	103.560	14.894	38.532
3000.00	90.725	104.065	14.895	40.021
3100.00	91.163	104.554	14.895	41.511
3200.00	91.589	105.027	14.896	43.000
3300.00	92.003	105.485	14.896	44.490
3400.00	92.406	105.930	14.897	45.980
3500.00	92.799	106.361	14.897	47.469
3600.00	93.181	106.781	14.897	48.959
3700.00	93.554	107.189	14.898	50.449
3800.00	93.919	107.587	14.898	51.938
3900.00	94.274	107.974	14.898	53.428
4000.00	94.621	108.351	14.899	54.918
4100.00	94.961	108.719	14.899	56.408
4200.00	95.292	109.078	14.899	57.898
4300.00	95.617	109.428	14.899	59.388
4400.00	95.935	109.771	14.900	60.878
4500.00	96.246	110.106	14.900	62.368
4600.00	96.551	110.433	14.900	63.858
4700.00	96.850	110.754	14.900	65.348
4800.00	97.143	111.067	14.900	66.838
4900.00	97.430	111.374	14.900	68.328
5000.00	97.712	111.676	14.901	69.818
5100.00	97.989	111.971	14.901	71.308
5200.00	98.260	112.260	14.901	72.798
5300.00	98.527	112.544	14.901	74.288
5400.00	98.789	112.822	14.901	75.778
5500.00	99.047	113.096	14.901	77.268
5600.00	99.300	113.364	14.901	78.758
5700.00	99.549	113.628	14.901	80.249
5800.00	99.794	113.887	14.901	81.739
5900.00	100.035	114.142	14.902	83.229
6000.00	100.272	114.392	14.902	84.719

THERMODYNAMIC FUNCTION OF $TeCl_3(s)$

$\Delta H^{\circ}_{f298} = -44$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	78.465	78.465	18.594	0
300.00	78.465	78.580	18.608	.034
400.00	79.202	84.013	19.126	1.924
500.00	80.609	88.312	19.383	3.851
600.00	82.197	91.860	19.528	5.797
700.00	83.799	94.877	19.617	7.755
800.00	85.351	97.501	19.676	9.720
900.00	86.832	99.821	19.717	11.690
1000.00	88.237	101.900	19.746	13.665
1100.00	89.566	103.783	19.768	15.638
1200.00	90.823	105.503	19.784	17.616
1300.00	92.014	107.087	19.797	19.595
1400.00	93.144	108.555	19.807	21.575
1500.00	94.217	109.922	19.816	23.557
1600.00	95.239	111.201	19.822	25.538
1700.00	96.214	112.403	19.828	27.521
1800.00	97.145	113.536	19.833	29.504
1900.00	98.036	114.609	19.837	31.488
2000.00	98.890	115.626	19.840	33.471
2100.00	99.711	116.594	19.843	35.456
2200.00	100.499	117.517	19.846	37.440
2300.00	101.258	118.400	19.848	39.425
2400.00	101.990	119.244	19.850	41.410
2500.00	102.697	120.055	19.852	43.395
2600.00	103.380	120.833	19.853	45.380
2700.00	104.040	121.583	19.855	47.365
2800.00	104.679	122.305	19.856	49.351
2900.00	105.299	123.001	19.857	51.336
3000.00	105.901	123.675	19.858	53.322
3100.00	106.485	124.326	19.859	55.308
3200.00	107.052	124.956	19.860	57.294
3300.00	107.604	125.567	19.860	59.280
3400.00	108.141	126.160	19.861	61.266
3500.00	108.664	126.736	19.862	63.252
3600.00	109.174	127.296	19.862	65.238
3700.00	109.671	127.840	19.863	67.225
3800.00	110.156	128.369	19.863	69.211
3900.00	110.630	128.885	19.864	71.197
4000.00	111.092	129.388	19.864	73.184
4100.00	111.545	129.879	19.864	75.170
4200.00	111.987	130.358	19.865	77.156
4300.00	112.420	130.825	19.865	79.143
4400.00	112.843	131.282	19.865	81.129
4500.00	113.258	131.728	19.866	83.116
4600.00	113.664	132.165	19.866	85.103
4700.00	114.062	132.592	19.866	87.089
4800.00	114.453	133.010	19.866	89.076
4900.00	114.836	133.420	19.867	91.062
5000.00	115.211	133.821	19.867	93.049
5100.00	115.580	134.215	19.867	95.036
5200.00	115.942	134.600	19.867	97.023
5300.00	116.298	134.979	19.867	99.009
5400.00	116.647	135.350	19.868	100.996
5500.00	116.991	135.715	19.868	102.983
5600.00	117.328	136.073	19.868	104.970
5700.00	117.660	136.424	19.868	106.956
5800.00	117.987	136.770	19.868	108.943
5900.00	118.308	137.110	19.868	110.930
6000.00	118.624	137.443	19.868	112.917

THERMODYNAMIC FUNCTION OF $TaCl_4(g)$

ΔH°_{f298} = -136 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	92.000	92.000	23.550	0
300.00	92.000	92.146	23.578	.044
400.00	92.940	99.082	24.550	2.457
500.00	94.740	104.614	25.000	4.937
600.00	96.779	109.196	25.244	7.450
700.00	98.838	113.099	25.392	9.983
800.00	100.838	116.496	25.487	12.527
900.00	102.748	119.502	25.553	15.079
1000.00	104.560	122.197	25.600	17.637
1100.00	106.276	124.639	25.635	20.199
1200.00	107.901	126.870	25.661	22.764
1300.00	109.440	128.925	25.682	25.331
1400.00	110.901	130.829	25.698	27.900
1500.00	112.289	132.603	25.711	30.470
1600.00	113.611	134.262	25.722	33.042
1700.00	114.872	135.822	25.731	35.615
1800.00	116.077	137.293	25.738	38.188
1900.00	117.231	138.685	25.745	40.762
2000.00	118.337	140.005	25.750	43.337
2100.00	119.399	141.262	25.755	45.912
2200.00	120.420	142.460	25.759	48.488
2300.00	121.403	143.605	25.762	51.064
2400.00	122.351	144.702	25.765	53.640
2500.00	123.267	145.753	25.768	56.217
2600.00	124.151	146.764	25.770	58.794
2700.00	125.007	147.737	25.773	61.371
2800.00	125.835	148.674	25.774	63.948
2900.00	126.639	149.579	25.776	66.526
3000.00	127.418	150.452	25.778	69.104
3100.00	128.175	151.298	25.779	71.681
3200.00	128.910	152.116	25.780	74.259
3300.00	129.625	152.910	25.782	76.838
3400.00	130.322	153.679	25.783	79.416
3500.00	131.000	154.427	25.784	81.994
3600.00	131.661	155.153	25.785	84.572
3700.00	132.305	155.859	25.785	87.151
3800.00	132.934	156.547	25.786	89.730
3900.00	133.548	157.217	25.787	92.308
4000.00	134.148	157.870	25.787	94.887
4100.00	134.734	158.507	25.788	97.466
4200.00	135.308	159.128	25.789	100.045
4300.00	135.869	159.735	25.789	102.623
4400.00	136.418	160.328	25.790	105.202
4500.00	136.956	160.907	25.790	107.781
4600.00	137.483	161.474	25.791	110.360
4700.00	137.999	162.029	25.791	112.939
4800.00	138.505	162.572	25.791	115.519
4900.00	139.002	163.104	25.792	118.098
5000.00	139.489	163.625	25.792	120.677
5100.00	139.968	164.135	25.792	123.256
5200.00	140.437	164.636	25.793	125.835
5300.00	140.898	165.128	25.793	128.415
5400.00	141.352	165.610	25.793	130.994
5500.00	141.797	166.083	25.793	133.573
5600.00	142.235	166.548	25.794	136.153
5700.00	142.665	167.004	25.794	138.732
5800.00	143.089	167.453	25.794	141.311
5900.00	143.506	167.894	25.794	143.891
6000.00	143.916	168.327	25.794	146.470

THERMODYNAMIC FUNCTION OF $TaCl_3$(c)

ΔH°_{f298} = -130.5 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	37.000	37.000	22.250	0
300.00	37.000	37.138	22.281	.041
400.00	37.891	43.731	23.497	2.336
500.00	39.609	49.062	24.270	4.727
600.00	41.568	53.542	24.868	7.184
700.00	43.561	57.415	25.383	9.697
800.00	45.511	60.835	25.854	12.260
900.00	47.387	63.906	26.300	14.867
1000.00	49.181	66.700	26.730	17.519
1100.00	50.892	69.267	27.150	20.213
1200.00	52.523	71.647	27.562	22.949
1300.00	54.081	73.869	27.969	25.725
1400.00	55.569	75.957	28.373	28.542
1500.00	56.995	77.928	28.774	31.400
1600.00	58.362	79.798	29.174	34.297
1700.00	59.676	81.579	29.571	37.235
1800.00	60.940	83.280	29.968	40.211
1900.00	62.159	84.911	30.363	43.228
2000.00	63.336	86.478	30.757	46.284
2100.00	64.474	87.988	31.151	49.379
2200.00	65.577	89.447	31.545	52.514
2300.00	66.645	90.858	31.938	55.688
2400.00	67.683	92.225	32.330	58.902
2500.00	68.691	93.553	32.723	62.155
2600.00	69.672	94.844	33.115	65.446
2700.00	70.628	96.101	33.507	68.777
2800.00	71.560	97.327	33.898	72.148
2900.00	72.469	98.523	34.290	75.557
3000.00	73.357	99.692	34.681	79.006
3100.00	74.225	100.836	35.072	82.493
3200.00	75.074	101.955	35.463	86.020
3300.00	75.905	103.053	35.854	89.586
3400.00	76.720	104.129	36.245	93.191
3500.00	77.518	105.185	36.636	96.835
3600.00	78.301	106.223	37.027	100.518
3700.00	79.069	107.243	37.418	104.240
3800.00	79.824	108.246	37.808	108.002
3900.00	80.565	109.233	38.199	111.802
4000.00	81.294	110.205	38.589	115.642
4100.00	82.011	111.162	38.980	119.520
4200.00	82.717	112.106	39.370	123.437
4300.00	83.411	113.037	39.761	127.394
4400.00	84.095	113.956	40.151	131.390
4500.00	84.768	114.863	40.542	135.424
4600.00	85.432	115.758	40.932	139.498
4700.00	86.087	116.642	41.322	143.611
4800.00	86.733	117.517	41.713	147.762
4900.00	87.370	118.381	42.103	151.953
5000.00	87.999	119.235	42.493	156.183
5100.00	88.619	120.080	42.883	160.452
5200.00	89.232	120.917	43.274	164.760
5300.00	89.838	121.745	43.664	169.107
5400.00	90.437	122.565	44.054	173.492
5500.00	91.028	123.377	44.444	177.917
5600.00	91.613	124.181	44.835	182.381
5700.00	92.191	124.978	45.225	186.884
5800.00	92.763	125.768	45.615	191.426
5900.00	93.329	126.551	46.005	196.007
6000.00	93.890	127.327	46.395	200.627

THERMODYNAMIC FUNCTION OF $ZnCl_4$(c)

ΔH°_{f298} = -168.8 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	46.000	46.000	28.638	0
300.00	46.001	46.177	28.678	.053
400.00	47.146	54.649	30.087	3.001
500.00	49.349	61.441	30.740	6.046
600.00	51.848	67.080	31.094	9.140
700.00	54.376	71.891	31.308	12.261
800.00	56.833	76.081	31.447	15.399
900.00	59.181	79.791	31.542	18.549
1000.00	61.412	83.118	31.610	21.706
1100.00	63.524	86.133	31.660	24.870
1200.00	65.525	88.890	31.699	28.038
1300.00	67.421	91.428	31.728	31.209
1400.00	69.221	93.780	31.752	34.383
1500.00	70.932	95.972	31.771	37.560
1600.00	72.562	98.023	31.787	40.738
1700.00	74.117	99.950	31.800	43.917
1800.00	75.603	101.768	31.810	47.097
1900.00	77.026	103.488	31.820	50.279
2000.00	78.390	105.121	31.827	53.461
2100.00	79.700	106.674	31.834	56.644
2200.00	80.960	108.155	31.840	59.828
2300.00	82.173	109.570	31.845	63.012
2400.00	83.343	110.926	31.850	66.197
2500.00	84.473	112.226	31.854	69.382
2600.00	85.564	113.475	31.857	72.568
2700.00	86.621	114.678	31.860	75.754
2800.00	87.643	115.836	31.863	78.940
2900.00	88.635	116.954	31.866	82.126
3000.00	89.597	118.035	31.868	85.313
3100.00	90.531	119.080	31.870	88.500
3200.00	91.439	120.092	31.872	91.687
3300.00	92.323	121.072	31.873	94.874
3400.00	93.182	122.024	31.875	98.062
3500.00	94.020	122.948	31.876	101.249
3600.00	94.836	123.846	31.878	104.437
3700.00	95.632	124.719	31.879	107.625
3800.00	96.408	125.569	31.880	110.813
3900.00	97.167	126.398	31.881	114.001
4000.00	97.908	127.205	31.882	117.189
4100.00	98.632	127.992	31.883	120.377
4200.00	99.340	128.760	31.884	123.565
4300.00	100.033	129.511	31.884	126.754
4400.00	100.711	130.244	31.885	129.942
4500.00	01.375	130.960	31.886	133.131
4600.00	102.026	131.661	31.886	136.319
4700.00	102.664	132.347	31.887	139.508
4800.00	103.290	133.018	31.887	142.697
4900.00	103.903	133.676	31.888	145.886
5000.00	104.505	134.320	31.888	149.074
5100.00	105.096	134.951	31.889	152.263
5200.00	105.676	135.570	31.889	155.452
5300.00	106.246	136.178	31.890	158.641
5400.00	106.805	136.774	31.890	161.830
5500.00	107.356	137.359	31.890	165.019
5600.00	107.897	137.934	31.891	168.208
5700.00	108.429	138.498	31.891	171.397
5800.00	108.952	139.053	31.891	174.586
5900.00	109.467	139.598	31.892	177.775
6000.00	109.973	140.134	31.892	180.965

THERMODYNAMIC FUNCTION OF $TaCl_5$(s)

ΔH°_{f298} = -183 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	100.000	100.000	27.438	0
300.00	100.001	100.170	27.489	.051
400.00	101.105	108.361	29.287	2.902
500.00	103.241	114.996	30.120	5.877
600.00	105.675	120.532	30.572	8.914
700.00	108.144	125.266	30.845	11.986
800.00	110.548	129.398	31.022	15.080
900.00	112.849	133.059	31.143	18.189
1000.00	115.037	136.345	31.230	21.307
1100.00	117.112	139.325	31.294	24.434
1200.00	119.078	142.050	31.343	27.566
1300.00	120.943	144.560	31.381	30.702
1400.00	122.714	146.887	31.411	33.842
1500.00	124.399	149.055	31.436	36.984
1600.00	126.004	151.084	31.455	40.129
1700.00	127.536	152.992	31.472	43.275
1800.00	129.000	154.791	31.486	46.423
1900.00	130.403	156.494	31.498	49.572
2000.00	131.748	158.110	31.507	52.722
2100.00	133.041	159.647	31.516	55.874
2200.00	134.283	161.113	31.524	59.026
2300.00	135.481	162.515	31.530	62.178
2400.00	136.635	163.857	31.536	65.332
2500.00	137.750	165.144	31.541	68.485
2600.00	138.828	166.381	31.545	71.640
2700.00	139.870	167.572	31.549	74.795
2800.00	140.880	168.719	31.553	77.950
2900.00	141.859	169.827	31.556	81.105
3000.00	142.810	170.897	31.559	84.261
3100.00	143.732	171.931	31.561	87.417
3200.00	144.629	172.933	31.564	90.573
3300.00	145.502	173.905	31.566	93.730
3400.00	146.351	174.847	31.568	96.886
3500.00	147.179	175.762	31.570	100.043
3600.00	147.985	176.652	31.571	103.200
3700.00	148.771	177.517	31.573	106.357
3800.00	149.539	178.359	31.574	109.515
3900.00	150.289	179.179	31.576	112.672
4000.00	151.021	179.978	31.577	115.830
4100.00	151.737	180.758	31.578	118.988
4200.00	152.437	181.519	31.579	122.146
4300.00	153.122	182.262	31.580	125.304
4400.00	153.792	182.988	31.581	128.462
4500.00	154.449	183.698	31.582	131.620
4600.00	155.092	184.392	31.583	134.778
4700.00	155.723	185.071	31.583	137.936
4800.00	156.341	185.736	31.584	141.095
4900.00	156.948	186.387	31.585	144.253
5000.00	157.543	187.026	31.585	147.411
5100.00	158.127	187.651	31.586	150.570
5200.00	158.701	188.264	31.586	153.729
5300.00	159.265	188.866	31.587	156.887
5400.00	159.818	189.456	31.587	160.046
5500.00	160.362	190.036	31.588	163.205
5600.00	160.897	190.605	31.588	166.364
5700.00	161.424	191.164	31.589	169.522
5800.00	161.941	191.714	31.589	172.681
5900.00	162.450	192.254	31.589	175.840
6000.00	162.951	192.785	31.590	178.999

THERMODYNAMIC FUNCTIONS OF TaC/c

ΔH°_{f298} = -34.6 KCAL/MOLE

(°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	10.110	10.110	8.792	0
300.00	10.110	10.164	8.822	.016
400.00	10.472	12.874	9.945	.961
500.00	11.188	15.169	10.605	1.990
600.00	12.020	17.146	11.082	3.076
700.00	12.879	18.885	11.473	4.204
800.00	13.729	20.440	11.817	5.369
900.00	14.554	21.850	12.136	6.567
1000.00	15.349	23.144	12.437	7.795
1100.00	16.113	24.344	12.728	9.054
1200.00	16.846	25.463	13.012	10.341
1300.00	17.550	26.516	13.290	11.656
1400.00	18.226	27.511	13.564	12.999
1500.00	18.877	28.456	13.836	14.369
1600.00	19.504	29.357	14.106	15.766
1700.00	20.109	30.221	14.374	17.190
1800.00	20.694	31.050	14.640	18.640
1900.00	21.260	31.848	14.906	20.118
2000.00	21.809	32.620	15.171	21.622
2100.00	22.342	33.366	15.435	23.152
2200.00	22.859	34.090	15.698	24.709
2300.00	23.363	34.793	15.900	26.289
2400.00	23.853	35.465	15.800	27.869
2500.00	24.331	36.110	15.800	29.449
2600.00	24.796	36.730	15.800	31.029
2700.00	25.249	37.326	15.800	32.609
2800.00	25.691	37.901	15.800	34.189
2900.00	26.121	38.455	15.800	35.769
3000.00	26.541	38.991	15.800	37.349
3100.00	26.951	39.509	15.800	38.929
3200.00	27.352	40.011	15.800	40.509
3300.00	27.743	40.497	15.800	42.089
3400.00	28.125	40.968	15.800	43.669
3500.00	28.498	41.426	15.800	45.249
3600.00	28.864	41.871	15.800	46.829
3700.00	29.221	42.304	15.800	48.409
3800.00	29.571	42.726	15.800	49.989
3900.00	29.913	43.136	15.800	51.569
4000.00	30.249	43.536	15.800	53.149
4100.00	30.578	43.926	15.800	54.729
4200.00	31.019	49.307	15.800	76.809
4300.00	31.449	49.679	15.800	78.389
4400.00	31.867	50.042	15.800	79.969
4500.00	32.275	50.397	15.800	81.549
4600.00	32.673	50.744	15.800	83.129
4700.00	33.061	51.084	15.800	84.709
4800.00	33.440	51.417	15.800	86.289
4900.00	33.810	51.743	15.800	87.869
5000.00	34.172	52.062	15.800	89.449
5100.00	34.526	52.375	15.800	91.029
5200.00	34.872	52.682	15.800	92.609
5300.00	35.211	52.982	15.800	94.189
5400.00	35.543	53.278	15.800	95.769
5500.00	35.868	53.568	15.800	97.349
5600.00	36.187	53.852	15.800	98.929
5700.00	36.499	54.132	15.800	100.509
5800.00	36.805	54.407	15.800	102.089
5900.00	37.106	54.677	15.800	103.669
6000.00	37.401	54.943	15.800	105.249

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF TaN/c

ΔH^{o}_{f298} = -60.0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	12.200	12.200	10.056	0
300.00	12.200	12.262	10.070	.019
400.00	12.604	15.266	10.850	1.065
500.00	13.394	17.771	11.630	2.189
600.00	14.309	19.960	12.410	3.391
700.00	15.260	21.932	13.190	4.671
800.00	16.208	23.744	13.970	6.029
900.00	17.141	25.435	14.750	7.465
1000.00	18.050	27.011	15.000	8.961
1100.00	18.931	28.440	15.000	10.461
1200.00	19.778	29.745	15.000	11.961
1300.00	20.592	30.946	15.000	13.461
1400.00	21.371	32.058	15.000	14.961
1500.00	22.119	33.093	15.000	16.461
1600.00	22.835	34.061	15.000	17.961
1700.00	23.523	34.970	15.000	19.461
1800.00	24.183	35.827	15.000	20.961
1900.00	24.817	36.638	15.000	22.461
2000.00	25.427	37.408	15.000	23.961
2100.00	26.015	38.140	15.000	25.461
2200.00	26.583	38.837	15.000	26.961
2300.00	27.130	39.504	15.000	28.461
2400.00	27.659	40.143	15.000	29.961
2500.00	28.171	40.755	15.000	31.461
2600.00	28.666	41.343	15.000	32.961
2700.00	29.146	41.909	15.000	34.461
2800.00	29.612	42.455	15.000	35.961
2900.00	30.064	42.981	15.000	37.461
3000.00	30.503	43.490	15.000	38.961
3100.00	30.930	43.982	15.000	40.461
3200.00	31.345	44.458	15.000	41.961
3300.00	31.749	44.919	15.000	43.461
3400.00	32.198	50.367	15.000	61.776
3500.00	32.723	50.802	15.000	63.276
3600.00	33.231	51.225	15.000	64.776
3700.00	33.723	51.636	15.000	66.276
3800.00	34.200	52.036	15.000	67.776
3900.00	34.662	52.425	15.000	69.276
4000.00	35.111	52.805	15.000	70.776
4100.00	35.547	53.175	15.000	72.276
4200.00	35.971	53.537	15.000	73.776
4300.00	36.384	53.890	15.000	75.276
4400.00	36.786	54.235	15.000	76.776
4500.00	37.177	54.572	15.000	78.276
4600.00	37.559	54.901	15.000	79.776
4700.00	37.931	55.224	15.000	81.276
4800.00	38.295	55.540	15.000	82.776
4900.00	38.650	55.849	15.000	84.276
5000.00	38.997	56.152	15.000	85.776
5100.00	39.336	56.449	15.000	87.276
5200.00	39.668	56.740	15.000	88.776
5300.00	39.993	57.026	15.000	90.276
5400.00	40.311	57.307	15.000	91.776
5500.00	40.623	57.582	15.000	93.276
5600.00	40.928	57.852	15.000	94.776
5700.00	41.227	58.118	15.000	96.276
5800.00	41.521	58.378	15.000	97.776
5900.00	41.808	58.635	15.000	99.276
6000.00	42.091	58.887	15.000	100.776

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF TaB_2/c

$\Delta H^{\circ}_{f298} = -50$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	9.180	9.180	10.167	0
300.00	9.180	9.243	10.281	.019
400.00	9.643	12.838	14.358	1.278
500.00	10.631	16.281	16.377	2.825
600.00	11.836	19.382	17.587	4.527
700.00	13.116	22.158	18.415	6.330
800.00	14.405	24.660	19.039	8.204
900.00	15.673	26.932	19.544	10.134
1000.00	16.904	29.014	19.976	12.110
1100.00	18.094	30.937	20.360	14.127
1200.00	19.239	32.723	20.711	16.181
1300.00	20.341	34.394	21.039	18.269
1400.00	21.402	35.965	21.350	20.388
1500.00	22.423	37.448	21.649	22.538
1600.00	23.406	38.855	21.938	24.718
1700.00	24.355	40.193	22.220	26.926
1800.00	25.270	41.471	22.497	29.162
1900.00	26.155	42.695	22.769	31.425
2000.00	27.012	43.869	23.037	33.715
2100.00	27.842	44.992	23.000	36.015
2200.00	28.646	46.062	23.000	38.315
2300.00	29.425	47.084	23.000	40.615
2400.00	30.181	48.063	23.000	42.915
2500.00	30.916	49.002	23.000	45.215
2600.00	31.629	49.904	23.000	47.515
2700.00	32.322	50.772	23.000	49.815
2800.00	32.996	51.608	23.000	52.115
2900.00	33.652	52.415	23.000	54.415
3000.00	34.290	53.195	23.000	56.715
3100.00	34.912	53.949	23.000	59.015
3200.00	35.519	54.680	23.000	61.315
3300.00	36.110	55.387	23.000	63.615
3400.00	36.687	56.074	23.000	65.915
3500.00	37.315	64.241	23.000	94.240
3600.00	38.072	64.889	23.000	96.540
3700.00	38.805	65.519	23.000	98.840
3800.00	39.516	66.132	23.000	101.140
3900.00	40.206	66.729	23.000	103.440
4000.00	40.877	67.312	23.000	105.740
4100.00	41.528	67.880	23.000	108.040
4200.00	42.163	68.434	23.000	110.340
4300.00	42.780	68.975	23.000	112.640
4400.00	43.381	69.504	23.000	114.940
4500.00	43.967	70.021	23.000	117.240
4600.00	44.539	70.526	23.000	119.540
4700.00	45.098	71.021	23.000	121.840
4800.00	45.643	71.505	23.000	124.140
4900.00	46.175	71.979	23.000	126.440
5000.00	46.696	72.444	23.000	128.740
5100.00	47.205	72.900	23.000	131.040
5200.00	47.704	73.346	23.000	133.340
5300.00	48.192	73.784	23.000	135.640
5400.00	48.670	74.214	23.000	137.940
5500.00	49.138	74.636	23.000	140.240
5600.00	49.597	75.051	23.000	142.540
5700.00	50.047	75.458	23.000	144.840
5800.00	50.489	75.858	23.000	147.140
5900.00	50.922	76.251	23.000	149.440
6000.00	51.347	76.637	23.000	151.740

THERMODYNAMIC FUNCTIONS OF TaOF(g)

ΔH°_{f298} = -76.3 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	63.392	63.392	12.238	0
300.00	63.392	63.467	12.256	.023
400.00	63.883	67.112	13.061	1.291
500.00	64.836	70.086	13.579	2.625
600.00	65.925	72.594	13.918	4.001
700.00	67.036	74.758	14.147	5.405
800.00	68.122	76.658	14.307	6.828
900.00	69.166	78.350	14.422	8.265
1000.00	70.162	79.874	14.508	9.712
1100.00	71.109	81.260	14.573	11.166
1200.00	72.009	82.530	14.623	12.626
1300.00	72.864	83.702	14.663	14.090
1400.00	73.677	84.790	14.695	15.558
1500.00	74.452	85.805	14.721	17.029
1600.00	75.192	86.756	14.743	18.502
1700.00	75.899	87.650	14.761	19.978
1800.00	76.575	88.494	14.776	21.454
1900.00	77.224	89.294	14.789	22.933
2000.00	77.846	90.052	14.800	24.412
2100.00	78.445	90.775	14.809	25.893
2200.00	79.021	91.464	14.818	27.374
2300.00	79.577	92.123	14.825	28.856
2400.00	80.113	92.754	14.831	30.339
2500.00	80.630	93.359	14.837	31.822
2600.00	81.131	93.941	14.842	33.306
2700.00	81.616	94.502	14.846	34.791
2800.00	82.086	95.042	14.850	36.276
2900.00	82.542	95.563	14.854	37.761
3000.00	82.984	96.066	14.857	39.246
3100.00	83.414	96.554	14.860	40.732
3200.00	83.832	97.025	14.863	42.218
3300.00	84.239	97.483	14.865	43.705
3400.00	84.635	97.927	14.868	45.191
3500.00	85.021	98.358	14.870	46.678
3600.00	85.397	98.776	14.871	48.165
3700.00	85.764	99.184	14.873	49.653
3800.00	86.123	99.581	14.875	51.140
3900.00	86.473	99.967	14.876	52.628
4000.00	86.815	100.344	14.878	54.115
4100.00	87.149	100.711	14.879	55.603
4200.00	87.477	101.070	14.880	57.091
4300.00	87.797	101.420	14.881	58.579
4400.00	88.110	101.762	14.882	60.067
4500.00	88.417	102.096	14.883	61.556
4600.00	88.718	102.423	14.884	63.044
4700.00	89.013	102.744	14.885	64.532
4800.00	89.303	103.057	14.886	66.021
4900.00	89.586	103.364	14.886	67.509
5000.00	89.865	103.665	14.887	68.998
5100.00	90.138	103.959	14.888	70.487
5200.00	90.407	104.249	14.888	71.976
5300.00	90.671	104.532	14.889	73.465
5400.00	90.930	104.810	14.890	74.955
5500.00	91.185	105.084	14.890	76.442
5600.00	91.436	105.352	14.891	77.931
5700.00	91.682	105.616	14.891	79.421
5800.00	91.925	105.874	14.891	80.910
5900.00	92.163	106.129	14.892	82.399
6000.00	92.398	106.379	14.892	83.888

THERMODYNAMIC FUNCTIONS OF TeOCL(g)

ΔH°_{f298} = -26.9 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	66.558	66.558	12.824	0
300.00	66.559	66.638	12.838	.024
400.00	67.070	70.420	13.442	1.340
500.00	68.054	73.465	13.841	2.705
600.00	69.174	76.014	14.107	4.104
700.00	70.311	78.203	14.290	5.524
800.00	71.420	80.120	14.418	6.960
900.00	72.483	81.824	14.511	8.406
1000.00	73.495	83.356	14.580	9.861
1100.00	74.456	84.749	14.633	11.322
1200.00	75.368	86.024	14.674	12.787
1300.00	76.233	87.200	14.707	14.257
1400.00	77.056	88.290	14.733	15.729
1500.00	77.839	89.308	14.754	17.203
1600.00	78.586	90.260	14.772	18.679
1700.00	79.299	91.156	14.787	20.157
1800.00	79.982	92.002	14.799	21.637
1900.00	80.636	92.802	14.809	23.117
2000.00	81.263	93.562	14.819	24.598
2100.00	81.866	94.285	14.826	26.081
2200.00	82.446	94.975	14.833	27.564
2300.00	83.006	95.635	14.839	29.047
2400.00	83.545	96.267	14.844	30.531
2500.00	84.066	96.873	14.849	32.016
2600.00	84.570	97.455	14.853	33.501
2700.00	85.058	98.016	14.857	34.987
2800.00	85.530	98.556	14.860	36.473
2900.00	85.988	99.078	14.863	37.959
3000.00	86.433	99.581	14.866	39.445
3100.00	86.865	100.069	14.868	40.932
3200.00	87.285	100.541	14.870	42.419
3300.00	87.694	100.999	14.872	43.906
3400.00	88.092	101.443	14.874	45.393
3500.00	88.479	101.874	14.876	46.881
3600.00	88.857	102.293	14.877	48.368
3700.00	89.226	102.701	14.879	49.856
3800.00	89.586	103.097	14.880	51.344
3900.00	89.937	103.484	14.881	52.832
4000.00	90.281	103.861	14.882	54.320
4100.00	90.616	104.228	14.883	55.809
4200.00	90.945	104.587	14.884	57.297
4300.00	91.266	104.937	14.885	58.785
4400.00	91.581	105.279	14.886	60.274
4500.00	91.889	105.614	14.887	61.763
4600.00	92.191	105.941	14.888	63.251
4700.00	92.487	106.261	14.888	64.740
4800.00	92.777	106.575	14.889	66.229
4900.00	93.062	106.882	14.890	67.718
5000.00	93.341	107.182	14.890	69.207
5100.00	93.615	107.477	14.891	70.696
5200.00	93.885	107.766	14.891	72.185
5300.00	94.149	108.050	14.892	73.674
5400.00	94.409	108.328	14.892	75.163
5500.00	94.665	108.602	14.893	76.653
5600.00	94.916	108.870	14.893	78.142
5700.00	95.163	109.134	14.893	79.631
5800.00	95.406	109.393	14.894	81.121
5900.00	95.644	109.647	14.894	82.610
6000.00	95.881	109.898	14.894	84.099

THERMODYNAMIC FUNCTIONS OF $TeO_2CL(g)$

ΔH°_{f298} = -117.9 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	69.500	69.500	15.573	0
300.00	69.500	69.596	15.616	.029
400.00	70.135	74.327	17.130	1.677
500.00	71.376	78.234	17.838	3.427
600.00	72.801	81.524	18.228	5.234
700.00	74.254	84.354	18.469	7.070
800.00	75.674	86.831	18.630	8.925
900.00	77.038	89.032	18.744	10.794
1000.00	78.338	91.012	18.830	12.673
1100.00	79.574	92.810	18.897	14.560
1200.00	80.746	94.456	18.951	16.452
1300.00	81.860	95.975	18.996	18.350
1400.00	82.919	97.384	19.034	20.251
1500.00	83.928	98.699	19.067	22.156
1600.00	84.890	99.930	19.097	24.064
1700.00	85.809	101.089	19.124	25.976
1800.00	86.688	102.183	19.149	27.889
1900.00	87.531	103.218	19.172	29.805
2000.00	88.341	104.202	19.193	31.724
2100.00	89.118	105.139	19.214	33.644
2200.00	89.867	106.034	19.233	35.566
2300.00	90.589	106.889	19.252	37.491
2400.00	91.285	107.709	19.270	39.417
2500.00	91.958	108.496	19.287	41.345
2600.00	92.609	109.253	19.304	43.274
2700.00	93.239	109.981	19.321	45.205
2800.00	93.849	110.684	19.337	47.138
2900.00	94.442	111.363	19.353	49.073
3000.00	95.017	112.020	19.368	51.009
3100.00	95.575	112.655	19.384	52.946
3200.00	96.119	113.270	19.399	54.886
3300.00	96.648	113.868	19.414	56.826
3400.00	97.163	114.447	19.429	58.768
3500.00	97.665	115.011	19.443	60.712
3600.00	98.154	115.559	19.456	62.657
3700.00	98.632	116.092	19.472	64.604
3800.00	99.098	116.612	19.487	66.551
3900.00	99.554	117.118	19.501	68.501
4000.00	99.999	117.612	19.515	70.452
4100.00	100.434	118.094	19.529	72.404
4200.00	100.861	118.565	19.544	74.358
4300.00	101.278	119.025	19.558	76.313
4400.00	101.686	119.475	19.571	78.269
4500.00	102.086	119.915	19.585	80.227
4600.00	102.479	120.345	19.599	82.186
4700.00	102.863	120.767	19.613	84.147
4800.00	103.241	121.180	19.627	86.109
4900.00	103.611	121.585	19.641	88.072
5000.00	103.974	121.982	19.654	90.037
5100.00	104.331	122.371	19.668	92.003
5200.00	104.682	122.753	19.682	93.970
5300.00	105.026	123.128	19.695	95.939
5400.00	105.365	123.496	19.709	97.910
5500.00	105.698	123.858	19.722	99.881
5600.00	106.025	124.214	19.736	101.854
5700.00	106.347	124.563	19.749	103.828
5800.00	106.663	124.907	19.763	105.804
5900.00	106.977	125.245	19.777	107.781
6000.00	107.284	125.577	19.790	109.759

THERMODYNAMIC FUNCTIONS OF $TaO_2F(g)$

ΔH°_{f298} = -167.2 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	71.000	71.000	15.263	0
300.00	71.000	71.095	15.310	.028
400.00	71.625	75.756	16.942	1.652
500.00	72.850	79.628	17.707	3.389
600.00	74.259	82.897	18.130	5.183
700.00	75.699	85.713	18.392	7.010
800.00	77.108	88.181	18.568	8.854
900.00	78.462	90.375	18.695	10.722
1000.00	79.754	92.350	18.790	12.596
1100.00	80.987	94.145	18.865	14.479
1200.00	82.148	95.789	18.926	16.369
1300.00	83.257	97.306	18.978	18.264
1400.00	84.311	98.714	19.022	20.164
1500.00	85.316	100.028	19.061	22.068
1600.00	86.274	101.259	19.096	23.976
1700.00	87.190	102.418	19.129	25.887
1800.00	88.067	103.512	19.158	27.802
1900.00	88.907	104.548	19.186	29.719
2000.00	89.714	105.533	19.212	31.639
2100.00	90.490	106.471	19.238	33.561
2200.00	91.237	107.367	19.262	35.486
2300.00	91.957	108.223	19.285	37.414
2400.00	92.652	109.045	19.307	39.343
2500.00	93.323	109.833	19.329	41.275
2600.00	93.973	110.592	19.350	43.209
2700.00	94.602	111.323	19.371	45.145
2800.00	95.212	112.027	19.392	47.083
2900.00	95.804	112.708	19.412	49.024
3000.00	96.378	113.367	19.432	50.966
3100.00	96.936	114.004	19.452	52.910
3200.00	97.480	114.622	19.471	54.856
3300.00	98.008	115.221	19.490	56.804
3400.00	98.523	115.804	19.510	58.754
3500.00	99.025	116.367	19.529	60.706
3600.00	99.514	116.920	19.547	62.660
3700.00	99.992	117.456	19.566	64.615
3800.00	100.458	117.978	19.585	66.573
3900.00	100.914	118.487	19.603	68.532
4000.00	101.360	118.983	19.622	70.494
4100.00	101.796	119.468	19.640	72.457
4200.00	102.222	119.941	19.658	74.422
4300.00	102.639	120.404	19.676	76.388
4400.00	103.048	120.857	19.695	78.357
4500.00	103.449	121.300	19.713	80.327
4600.00	103.842	121.733	19.731	82.299
4700.00	104.227	122.158	19.749	84.273
4800.00	104.605	122.574	19.767	86.249
4900.00	104.976	122.981	19.785	88.227
5000.00	105.340	123.381	19.802	90.206
5100.00	105.698	123.773	19.820	92.187
5200.00	106.049	124.159	19.838	94.170
5300.00	106.394	124.537	19.856	96.155
5400.00	106.734	124.908	19.874	98.141
5500.00	107.067	125.273	19.891	100.130
5600.00	107.396	125.631	19.909	102.120
5700.00	107.719	125.984	19.927	104.111
5800.00	108.037	126.331	19.945	106.105
5900.00	108.350	126.672	19.962	108.100
6000.00	108.658	127.007	19.980	110.097

THERMODYNAMIC FUNCTIONS OF $TaOF_2(g)$

$\Delta H^{\circ}_{f298} = -202.5$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	72.500	72.500	14.913	0
300.00	72.500	72.592	14.947	.028
400.00	73.104	77.079	16.135	1.590
500.00	74.277	80.747	16.700	3.235
600.00	75.619	83.822	17.019	4.922
700.00	76.984	86.462	17.221	6.639
800.00	78.316	88.771	17.362	8.364
900.00	79.594	90.823	17.467	10.106
1000.00	80.810	92.667	17.550	11.857
1100.00	81.966	94.343	17.618	13.616
1200.00	83.062	95.879	17.676	15.380
1300.00	84.103	97.296	17.727	17.151
1400.00	85.093	98.611	17.773	18.926
1500.00	86.036	99.839	17.816	20.705
1600.00	84.935	100.990	17.855	22.489
1700.00	87.794	102.074	17.892	24.276
1800.00	88.616	103.097	17.928	26.067
1900.00	89.404	104.067	17.962	27.862
2000.00	90.160	104.990	17.995	29.659
2100.00	90.887	105.868	18.027	31.460
2200.00	91.587	106.708	18.058	33.265
2300.00	92.262	107.511	18.089	35.072
2400.00	92.914	108.282	18.119	36.882
2500.00	93.544	109.022	18.149	38.694
2600.00	94.153	109.734	18.179	40.512
2700.00	94.743	110.421	18.208	42.332
2800.00	95.314	111.084	18.237	44.154
2900.00	95.869	111.724	18.265	45.979
3000.00	96.408	112.344	18.294	47.807
3100.00	96.932	112.944	18.322	49.638
3200.00	97.441	113.526	18.350	51.471
3300.00	97.937	114.091	18.378	53.308
3400.00	98.421	114.640	18.406	55.147
3500.00	98.892	115.174	18.433	56.989
3600.00	99.351	115.694	18.461	58.833
3700.00	99.800	116.200	18.488	60.681
3800.00	100.238	116.694	18.516	62.531
3900.00	100.666	117.175	18.543	64.384
4000.00	101.085	117.645	18.571	66.240
4100.00	101.494	118.104	18.598	68.098
4200.00	101.895	118.557	18.625	69.959
4300.00	102.288	118.991	18.652	71.823
4400.00	102.672	119.420	18.679	73.690
4500.00	103.049	119.840	18.707	75.559
4600.00	103.418	120.251	18.734	77.431
4700.00	103.781	120.654	18.761	79.306
4800.00	104.137	121.050	18.788	81.183
4900.00	104.486	121.437	18.815	83.063
5000.00	104.829	121.818	18.842	84.946
5100.00	105.165	122.191	18.868	86.832
5200.00	105.496	122.558	18.895	88.720
5300.00	105.822	122.918	18.922	90.611
5400.00	106.141	123.272	18.949	92.504
5500.00	106.456	123.620	18.976	94.401
5600.00	106.766	123.962	19.003	96.299
5700.00	107.070	124.299	19.030	98.201
5800.00	107.370	124.630	19.056	100.105
5900.00	107.666	124.956	19.083	102.012
6000.00	107.956	125.277	19.110	103.922

THERMODYNAMIC FUNCTIONS OF $TaOCl_2(g)$

$\Delta H^{\circ}_{f298} = -103.8$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	74.000	74.000	15.937	0
300.00	74.000	74.096	15.959	.029
400.00	74.625	78.722	16.511	1.639
500.00	75.830	82.460	16.962	3.315
600.00	77.202	85.577	17.215	5.025
700.00	78.593	88.243	17.375	6.755
800.00	79.948	90.571	17.485	8.498
900.00	81.245	92.636	17.567	10.251
1000.00	82.479	94.490	17.630	12.011
1100.00	83.648	96.173	17.682	13.777
1200.00	84.757	97.713	17.725	15.547
1300.00	85.809	99.133	17.763	17.322
1400.00	86.808	100.451	17.797	19.100
1500.00	87.759	101.680	17.828	20.881
1600.00	88.666	102.831	17.857	22.665
1700.00	89.531	103.915	17.883	24.452
1800.00	90.359	104.938	17.909	26.242
1900.00	91.152	105.907	17.933	28.034
2000.00	91.913	106.827	17.957	29.828
2100.00	92.644	107.704	17.979	31.625
2200.00	93.348	108.541	18.002	33.424
2300.00	94.026	109.341	18.023	35.225
2400.00	94.680	110.109	18.044	37.029
2500.00	95.312	110.846	18.065	38.834
2600.00	95.923	111.555	18.086	40.642
2700.00	96.515	112.238	18.106	42.452
2800.00	97.088	112.897	18.126	44.263
2900.00	97.645	113.533	18.146	46.077
3000.00	98.184	114.149	18.166	47.892
3100.00	98.709	114.745	18.186	49.710
3200.00	99.219	115.322	18.205	51.530
3300.00	99.716	115.883	18.225	53.351
3400.00	100.199	116.427	18.244	55.174
3500.00	100.671	116.956	18.263	57.000
3600.00	101.130	117.471	18.282	58.827
3700.00	101.579	117.972	18.301	60.656
3800.00	102.016	118.460	18.320	62.487
3900.00	102.444	118.937	18.339	64.320
4000.00	102.862	119.401	18.358	66.155
4100.00	103.271	119.855	18.377	67.992
4200.00	103.671	120.298	18.396	69.830
4300.00	104.063	120.731	18.414	71.671
4400.00	104.447	121.154	18.433	73.513
4500.00	104.823	121.569	18.452	75.358
4600.00	105.191	121.975	18.471	77.204
4700.00	105.552	122.372	18.489	79.052
4800.00	105.907	122.761	18.508	80.902
4900.00	106.255	123.143	18.526	82.753
5000.00	106.596	123.518	18.545	84.607
5100.00	106.932	123.885	18.564	86.462
5200.00	107.261	124.246	18.582	88.320
5300.00	107.585	124.600	18.601	90.179
5400.00	107.903	124.948	18.619	92.040
5500.00	108.216	125.290	18.638	93.902
5600.00	108.524	125.626	18.656	95.767
5700.00	108.827	125.956	18.675	97.634
5800.00	109.125	126.281	18.693	99.502
5900.00	109.419	126.601	18.711	101.372
6000.00	109.708	126.915	18.730	103.244

THERMODYNAMIC FUNCTIONS OF $ThOF_3$(s)

ΔH°_{f298} = -335.3 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	76.000	76.000	18.663	0
300.00	76.000	76.116	18.705	.035
400.00	76.756	81.731	20.199	1.940
500.00	78.225	86.323	20.911	4.049
600.00	79.904	90.175	21.315	6.162
700.00	81.613	93.481	21.574	8.308
800.00	83.281	96.374	21.755	10.475
900.00	84.881	98.945	21.892	12.657
1000.00	86.405	101.257	22.000	14.852
1100.00	87.853	103.359	22.090	17.057
1200.00	89.226	105.284	22.169	19.271
1300.00	90.531	107.061	22.237	21.493
1400.00	91.771	108.711	22.299	23.717
1500.00	92.952	110.252	22.357	25.950
1600.00	94.079	111.697	22.412	28.188
1700.00	95.156	113.057	22.463	30.432
1800.00	96.186	114.342	22.512	32.681
1900.00	97.174	115.561	22.560	34.934
2000.00	98.123	116.719	22.606	37.193
2100.00	99.035	117.823	22.651	39.455
2200.00	99.913	118.878	22.696	41.723
2300.00	100.760	119.888	22.739	43.995
2400.00	101.577	120.856	22.782	46.271
2500.00	102.367	121.787	22.824	48.551
2600.00	103.131	122.683	22.866	50.835
2700.00	103.871	123.547	22.907	53.124
2800.00	104.589	124.381	22.948	55.417
2900.00	105.285	125.187	22.989	57.714
3000.00	105.962	125.967	23.030	60.015
3100.00	106.620	126.723	23.070	62.320
3200.00	107.259	127.456	23.110	64.629
3300.00	107.882	128.167	23.150	66.942
3400.00	108.489	128.859	23.190	69.259
3500.00	109.081	129.532	23.229	71.580
3600.00	109.658	130.187	23.269	73.905
3700.00	110.221	130.825	23.308	76.233
3800.00	110.772	131.447	23.348	78.566
3900.00	111.310	132.054	23.387	80.903
4000.00	111.836	132.647	23.426	83.244
4100.00	112.350	133.226	23.465	85.588
4200.00	112.854	133.792	23.504	87.937
4300.00	113.348	134.345	23.543	90.289
4400.00	113.831	134.887	23.582	92.645
4500.00	114.305	135.417	23.621	95.005
4600.00	114.769	135.937	23.660	97.369
4700.00	115.225	136.446	23.698	99.737
4800.00	115.673	136.945	23.737	102.109
4900.00	116.112	137.435	23.776	104.485
5000.00	116.543	137.916	23.815	106.864
5100.00	116.967	138.388	23.853	109.248
5200.00	117.383	138.851	23.892	111.635
5300.00	117.792	139.307	23.930	114.026
5400.00	118.195	139.755	23.969	116.421
5500.00	118.591	140.195	24.008	118.820
5600.00	118.981	140.628	24.046	121.223
5700.00	119.364	141.054	24.085	123.629
5800.00	119.742	141.473	24.123	126.040
5900.00	120.114	141.885	24.162	128.454
6000.00	120.480	142.292	24.200	130.872

THERMODYNAMIC FUNCTIONS OF $TaOCl_3$(s)

ΔH°_{f298} = -187.2 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K	H^T_{298} (kcal/mole)
298.15	86.400	86.400	19.631	0
300.00	86.40C	86.521	19.639	.036
400.00	87.176	92.228	20.052	2.021
500.00	88.653	96.747	20.465	4.047
600.00	90.325	100.514	20.878	6.114
700.00	92.018	103.764	21.291	8.222
800.00	93.669	106.634	21.704	10.372
900.00	95.255	109.214	22.117	12.563
1000.00	96.770	111.566	22.530	14.795
1100.00	98.214	113.713	22.542	17.049
1200.00	99.589	115.675	22.564	19.304
1300.00	100.897	117.482	22.586	21.561
1400.00	102.142	119.157	22.608	23.821
1500.00	103.329	120.717	22.630	26.083
1600.00	104.462	122.179	22.652	28.347
1700.00	105.545	123.553	22.674	30.613
1800.00	106.581	124.849	22.696	32.882
1900.00	107.576	126.077	22.718	35.153
2000.00	108.530	127.243	22.740	37.425
2100.00	109.448	128.353	22.762	39.701
2200.00	110.331	129.412	22.784	41.978
2300.00	111.183	130.425	22.806	44.257
2400.00	112.005	131.397	22.828	46.539
2500.00	112.800	132.329	22.850	48.823
2600.00	113.568	133.225	22.872	51.109
2700.00	114.312	134.089	22.894	53.397
2800.00	115.034	134.922	22.916	55.688
2900.00	115.733	135.727	22.938	57.981
3000.00	116.413	136.505	22.960	60.275
3100.00	117.073	137.258	22.982	62.573
3200.00	117.715	137.988	23.004	64.872
3300.00	118.340	138.696	23.026	67.173
3400.00	118.949	139.384	23.048	69.477
3500.00	119.543	140.052	23.070	71.783
3600.00	120.122	140.702	23.092	74.091
3700.00	120.686	141.335	23.114	76.401
3800.00	121.238	141.952	23.136	78.714
3900.00	121.777	142.553	23.158	81.029
4000.00	122.304	143.140	23.180	83.345
4100.00	122.819	143.713	23.202	85.665
4200.00	123.323	144.272	23.224	87.986
4300.00	123.816	144.819	23.246	90.309
4400.00	124.300	145.353	23.268	92.635
4500.00	124.774	145.876	23.290	94.963
4600.00	125.238	146.389	23.312	97.293
4700.00	125.693	146.890	23.334	99.625
4800.00	126.140	147.382	23.356	101.960
4900.00	126.578	147.863	23.378	104.297
5000.00	127.009	148.336	23.400	106.635
5100.00	127.432	148.800	23.422	108.977
5200.00	127.847	149.255	23.444	111.320
5300.00	128.255	149.701	23.466	113.665
5400.00	128.656	150.140	23.488	116.013
5500.00	129.051	150.571	23.510	118.363
5600.00	129.439	150.995	23.532	120.715
5700.00	129.821	151.412	23.554	123.069
5800.00	130.197	151.822	23.576	125.426
5900.00	130.567	152.225	23.598	127.785
6000.00	130.931	152.622	23.620	130.145

3.3 TUNGSTEN SPECIES

THERMODYNAMIC FUNCTIONS OF $WF_2(g)$

ΔH°_{f298} = -3.3 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	63.971	63.971	13.040	0
300.00	63.972	64.052	13.057	.024
400.00	64.495	67.910	13.730	1.367
500.00	65.497	71.018	14.105	2.760
600.00	66.640	73.611	14.330	4.183
700.00	67.798	75.852	14.473	5.624
800.00	68.926	77.771	14.570	7.076
900.00	70.006	79.491	14.637	8.537
1000.00	71.033	81.036	14.687	10.003
1100.00	72.007	82.438	14.723	11.474
1200.00	72.931	83.720	14.752	12.947
1300.00	73.807	84.902	14.774	14.424
1400.00	74.639	85.997	14.791	15.902
1500.00	75.430	87.018	14.806	17.382
1600.00	76.185	87.974	14.818	18.863
1700.00	76.905	88.873	14.827	20.345
1800.00	77.594	89.721	14.836	21.828
1900.00	78.255	90.523	14.842	23.312
2000.00	78.886	91.284	14.848	24.797
2100.00	79.494	92.009	14.854	26.282
2200.00	80.078	92.700	14.858	27.768
2300.00	80.642	93.361	14.862	29.254
2400.00	81.185	93.993	14.865	30.740
2500.00	81.709	94.600	14.868	32.227
2600.00	82.216	95.183	14.871	33.714
2700.00	82.707	95.744	14.873	35.201
2800.00	83.182	96.285	14.876	36.688
2900.00	83.643	96.807	14.877	38.176
3000.00	84.091	97.312	14.879	39.664
3100.00	84.525	97.800	14.881	41.152
3200.00	84.947	98.272	14.882	42.640
3300.00	85.358	98.730	14.883	44.128
3400.00	85.758	99.175	14.885	45.617
3500.00	86.147	99.606	14.886	47.105
3600.00	86.527	100.025	14.887	48.594
3700.00	86.897	100.433	14.888	50.083
3800.00	87.259	100.830	14.889	51.571
3900.00	87.612	101.217	14.889	53.060
4000.00	87.957	101.594	14.890	54.549
4100.00	88.294	101.962	14.891	56.038
4200.00	88.624	102.321	14.891	57.527
4300.00	88.946	102.671	14.892	59.017
4400.00	89.262	103.013	14.892	60.506
4500.00	89.571	103.348	14.893	61.995
4600.00	89.874	103.675	14.893	63.484
4700.00	90.171	103.996	14.894	64.974
4800.00	90.463	104.309	14.894	66.465
4900.00	90.748	104.616	14.895	67.953
5000.00	91.029	104.917	14.895	69.442
5100.00	91.304	105.212	14.895	70.932
5200.00	91.574	105.501	14.896	72.421
5300.00	91.840	105.785	14.896	73.911
5400.00	92.101	106.064	14.896	75.400
5500.00	92.357	106.337	14.897	76.890
5600.00	92.609	106.605	14.897	78.380
5700.00	92.857	106.869	14.897	79.869
5800.00	93.101	107.128	14.897	81.359
5900.00	93.341	107.383	14.898	82.849
6000.00	93.577	107.633	14.898	84.339

THERMODYNAMIC FUNCTIONS OF WF_4(g)

ΔH°_{f298} = -210 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	83.697	83.697	20.978	0
300.00	83.697	83.827	21.014	.039
400.00	84.541	90.085	22.416	2.218
500.00	86.175	95.178	23.194	4.502
600.00	88.041	99.451	23.659	6.846
700.00	89.940	103.122	23.954	9.228
800.00	91.792	106.334	24.153	11.634
900.00	93.570	109.188	24.292	14.056
1000.00	95.262	111.753	24.393	16.491
1100.00	96.868	114.081	24.469	18.934
1200.00	98.393	116.213	24.527	21.384
1300.00	99.840	118.178	24.572	23.839
1400.00	101.216	120.000	24.609	26.298
1500.00	102.525	121.699	24.638	28.761
1600.00	103.774	123.290	24.662	31.226
1700.00	104.967	124.786	24.682	33.693
1800.00	106.107	126.197	24.699	36.162
1900.00	107.200	127.533	24.714	38.633
2000.00	108.249	128.801	24.726	41.105
2100.00	109.256	130.008	24.736	43.578
2200.00	110.226	131.158	24.746	46.052
2300.00	111.160	132.259	24.754	48.527
2400.00	112.061	133.312	24.761	51.002
2500.00	112.932	134.323	24.767	53.479
2600.00	113.773	135.295	24.772	55.956
2700.00	114.588	136.230	24.777	58.433
2800.00	115.377	137.131	24.782	60.911
2900.00	116.142	138.001	24.785	63.390
3000.00	116.885	138.841	24.789	65.868
3100.00	117.606	139.654	24.792	68.347
3200.00	118.308	140.441	24.795	70.827
3300.00	118.990	141.204	24.798	73.306
3400.00	119.654	141.944	24.800	75.786
3500.00	120.301	142.663	24.803	78.266
3600.00	120.932	143.362	24.805	80.747
3700.00	121.548	144.042	24.806	83.227
3800.00	122.148	144.703	24.808	85.708
3900.00	122.735	145.348	24.810	88.189
4000.00	123.308	145.976	24.811	90.670
4100.00	123.869	146.588	24.813	93.151
4200.00	124.417	147.186	24.814	95.633
4300.00	124.953	147.770	24.815	98.114
4400.00	125.478	148.341	24.816	100.596
4500.00	125.992	148.898	24.817	103.077
4600.00	126.496	149.444	24.818	105.559
4700.00	126.990	149.978	24.819	108.041
4800.00	127.475	150.500	24.820	110.523
4900.00	127.950	151.012	24.821	113.005
5000.00	128.416	151.513	24.822	115.487
5100.00	128.874	152.005	24.822	117.969
5200.00	129.323	152.487	24.823	120.452
5300.00	129.765	152.960	24.824	122.934
5400.00	130.199	153.424	24.824	125.416
5500.00	130.625	153.879	24.825	127.899
5600.00	131.044	154.327	24.825	130.381
5700.00	131.457	154.766	24.826	132.864
5800.00	131.862	155.198	24.826	135.346
5900.00	132.261	155.622	24.827	137.829
6000.00	132.654	156.039	24.827	140.312

THERMODYNAMIC FUNCTIONS OF WF_5(g)

ΔH^{o}_{f298} = -384 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	85.000	85.000	24.719	0
300.00	85.000	85.153	24.794	.046
400.00	86.012	92.702	27.432	2.676
500.00	87.995	98.969	28.655	5.487
600.00	90.277	104.258	29.322	8.389
700.00	92.607	108.811	29.725	11.343
800.00	94.887	112.798	29.988	14.329
900.00	97.077	116.341	30.169	17.338
1000.00	99.166	119.527	30.300	20.361
1100.00	101.150	122.420	30.398	23.397
1200.00	103.035	125.068	30.473	26.440
1300.00	104.825	127.510	30.532	29.491
1400.00	106.527	129.774	30.580	32.546
1500.00	108.148	131.885	30.619	35.606
1600.00	109.694	133.863	30.652	38.670
1700.00	111.171	135.722	30.680	41.737
1800.00	112.584	137.476	30.704	44.806
1900.00	113.936	139.137	30.725	47.877
2000.00	115.238	140.713	30.743	50.951
2100.00	116.487	142.214	30.760	54.026
2200.00	117.685	143.645	30.774	57.103
2300.00	118.846	145.013	30.787	60.181
2400.00	119.965	146.324	30.799	63.260
2500.00	121.045	147.581	30.811	66.341
2600.00	122.089	148.790	30.821	69.422
2700.00	123.100	149.953	30.830	72.505
2800.00	124.079	151.075	30.839	75.588
2900.00	125.029	152.157	30.848	78.673
3000.00	125.950	153.203	30.855	81.758
3100.00	126.846	154.215	30.863	84.844
3200.00	127.717	155.195	30.870	87.930
3300.00	128.564	156.145	30.877	91.018
3400.00	129.389	157.067	30.884	94.106
3500.00	130.192	157.962	30.890	97.194
3600.00	130.976	158.832	30.896	100.284
3700.00	131.740	159.679	30.902	103.374
3800.00	132.486	160.503	30.908	106.464
3900.00	133.215	161.306	30.913	109.555
4000.00	133.927	162.089	30.919	112.647
4100.00	134.623	162.852	30.924	115.739
4200.00	135.304	163.597	30.929	118.831
4300.00	135.971	164.325	30.934	121.925
4400.00	136.624	165.037	30.939	125.018
4500.00	137.262	165.732	30.944	128.113
4600.00	137.886	166.412	30.949	131.207
4700.00	138.503	167.078	30.954	134.302
4800.00	139.105	167.729	30.959	137.398
4900.00	139.696	168.368	30.963	140.494
5000.00	140.275	168.993	30.968	143.591
5100.00	140.844	169.607	30.972	146.688
5200.00	141.403	170.208	30.977	149.785
5300.00	141.952	170.798	30.981	152.883
5400.00	142.492	171.377	30.986	155.981
5500.00	143.022	171.946	30.990	159.080
5600.00	143.544	172.504	30.994	162.179
5700.00	144.057	173.053	30.999	165.279
5800.00	144.561	173.592	31.003	168.379
5900.00	145.058	174.122	31.007	171.480
6000.00	145.547	174.643	31.011	174.581

THERMODYNAMIC FUNCTIONS OF $MoO_2F_2(g)$

ΔH°_{f298} = -246 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	74.000	74.000	18.303	0
300.00	74.000	74.113	18.356	.034
400.00	74.747	79.685	20.206	1.975
500.00	76.210	84.298	21.077	4.044
600.00	77.891	88.186	21.563	6.178
700.00	79.607	91.536	21.867	8.351
800.00	81.285	94.470	22.074	10.548
900.00	82.898	97.079	22.224	12.764
1000.00	84.435	99.427	22.340	14.992
1100.00	85.896	101.561	22.432	17.231
1200.00	87.284	103.516	22.509	19.478
1300.00	88.603	105.320	22.575	21.732
1400.00	89.858	106.996	22.633	23.993
1500.00	91.053	108.559	22.686	26.259
1600.00	92.194	110.025	22.733	28.530
1700.00	93.283	111.404	22.777	30.805
1800.00	94.327	112.707	22.819	33.085
1900.00	95.327	113.942	22.858	35.369
2000.00	96.287	115.115	22.896	37.657
2100.00	97.211	116.233	22.932	39.948
2200.00	98.100	117.301	22.967	42.243
2300.00	98.957	118.323	23.001	44.541
2400.00	99.784	119.302	23.034	46.843
2500.00	100.584	120.243	23.067	49.148
2600.00	101.358	121.149	23.099	51.457
2700.00	102.107	122.021	23.131	53.768
2800.00	102.833	122.863	23.162	56.083
2900.00	103.538	123.676	23.192	58.400
3000.00	104.222	124.463	23.223	60.721
3100.00	104.888	125.225	23.253	63.045
3200.00	105.535	125.964	23.283	65.372
3300.00	106.165	126.680	23.312	67.701
3400.00	106.779	127.377	23.342	70.034
3500.00	107.377	128.054	23.371	72.370
3600.00	107.960	128.713	23.400	74.708
3700.00	108.530	129.354	23.429	77.050
3800.00	109.086	129.979	23.458	79.394
3900.00	109.630	130.589	23.487	81.742
4000.00	110.161	131.184	23.516	84.092
4100.00	110.681	131.765	23.544	86.445
4200.00	111.190	132.333	23.573	88.801
4300.00	111.688	132.888	23.601	91.159
4400.00	112.176	133.431	23.630	93.521
4500.00	112.654	133.962	23.658	95.885
4600.00	113.123	134.482	23.686	98.252
4700.00	113.583	134.992	23.715	100.622
4800.00	114.034	135.492	23.743	102.995
4900.00	114.477	135.982	23.771	105.371
5000.00	114.912	136.462	23.799	107.750
5100.00	115.339	136.934	23.827	110.131
5200.00	115.759	137.397	23.855	112.515
5300.00	116.172	137.851	23.883	114.902
5400.00	116.577	138.298	23.911	117.292
5500.00	116.976	138.737	23.939	119.684
5600.00	117.369	139.168	23.967	122.079
5700.00	117.755	139.593	23.995	124.477
5800.00	118.135	140.011	24.023	126.878
5900.00	118.509	140.421	24.051	129.282
6000.00	118.876	140.826	24.078	131.688

THERMODYNAMIC FUNCTIONS OF $MoF_2(g)$

ΔH^{o}_{f298} = -96 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	70.000	70.000	15.100	0
300.00	70.000	70.094	15.132	.028
400.00	70.610	74.626	16.271	1.606
500.00	71.795	78.321	16.811	3.263
600.00	73.147	81.415	17.117	4.961
700.00	74.523	84.069	17.311	6.683
800.00	75.864	86.390	17.446	8.421
900.00	77.150	88.451	17.547	10.171
1000.00	78.374	90.304	17.626	11.930
1100.00	79.537	91.987	17.691	13.696
1200.00	80.639	93.529	17.747	15.467
1300.00	81.686	94.951	17.796	17.245
1400.00	82.681	96.272	17.840	19.026
1500.00	83.629	97.504	17.880	20.812
1600.00	84.533	98.659	17.918	22.602
1700.00	85.396	99.747	17.954	24.396
1800.00	86.222	100.774	17.988	26.193
1900.00	87.014	101.747	18.021	27.994
2000.00	87.774	102.672	18.052	29.797
2100.00	88.504	103.554	18.083	31.604
2200.00	89.208	104.396	18.113	33.414
2300.00	89.886	105.202	18.143	35.227
2400.00	90.540	105.974	18.172	37.042
2500.00	91.172	106.717	18.200	38.861
2600.00	91.784	107.431	18.229	40.682
2700.00	92.375	108.120	18.257	42.507
2800.00	92.951	108.784	18.284	44.334
2900.00	93.508	109.426	18.312	46.164
3000.00	94.049	110.047	18.339	47.996
3100.00	94.575	110.649	18.366	49.831
3200.00	95.086	111.233	18.393	51.669
3300.00	95.584	111.799	18.420	53.510
3400.00	96.069	112.349	18.447	55.353
3500.00	96.542	112.885	18.473	57.199
3600.00	97.003	113.405	18.500	59.048
3700.00	97.453	113.913	18.526	60.899
3800.00	97.893	114.407	18.552	62.753
3900.00	98.324	114.889	18.579	64.610
4000.00	98.744	115.360	18.605	66.469
4100.00	99.154	115.820	18.631	68.331
4200.00	99.556	116.269	18.657	70.195
4300.00	99.950	116.708	18.683	72.062
4400.00	100.335	117.138	18.709	73.932
4500.00	100.713	117.559	18.735	75.804
4600.00	101.084	117.971	18.761	77.679
4700.00	101.448	118.375	18.787	79.556
4800.00	101.805	118.770	18.813	81.436
4900.00	102.155	119.159	18.839	83.319
5000.00	102.499	119.539	18.865	85.204
5100.00	102.836	119.913	18.891	87.092
5200.00	103.168	120.280	18.916	88.982
5300.00	103.495	120.641	18.942	90.875
5400.00	103.815	120.995	18.968	92.771
5500.00	104.131	121.344	18.994	94.669
5600.00	104.441	121.686	19.020	96.569
5700.00	104.747	122.023	19.045	98.473
5800.00	105.048	122.354	19.071	100.378
5900.00	105.344	122.681	19.097	102.287
6000.00	105.635	123.002	19.122	104.198

THERMODYNAMIC FUNCTIONS OF WC/c

ΔH^{o}_{f298} = -9.7 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	8.500	8.500	7.835	0
300.00	8.500	8.549	7.879	.015
400.00	8.832	11.063	9.466	.892
500.00	9.504	13.269	10.257	1.882
600.00	10.295	15.184	10.734	2.934
700.00	11.116	16.865	11.064	4.024
800.00	11.930	18.359	11.315	5.144
900.00	12.720	19.704	11.520	6.286
1000.00	13.481	20.927	11.696	7.447
1100.00	14.209	22.050	11.854	8.624
1200.00	14.906	23.087	11.999	9.817
1300.00	15.573	24.053	12.136	11.024
1400.00	16.212	24.957	12.265	12.244
1500.00	16.823	25.808	12.391	13.477
1600.00	17.410	26.612	12.512	14.722
1700.00	17.974	27.374	12.631	15.979
1800.00	18.517	28.099	12.747	17.248
1900.00	19.039	28.791	12.862	18.529
2000.00	19.544	29.454	12.975	19.820
2100.00	20.031	30.089	13.087	21.123
2200.00	20.502	30.701	13.198	22.438
2300.00	20.958	31.290	13.308	23.763
2400.00	21.401	31.859	13.418	25.099
2500.00	21.830	32.409	13.527	26.447
2600.00	22.247	32.941	13.636	27.805
2700.00	22.653	33.458	13.744	29.174
2800.00	23.048	33.960	13.852	30.554
2900.00	23.432	34.448	13.960	31.944
3000.00	23.808	34.923	14.067	33.346
3100.00	24.174	35.386	14.174	34.758
3200.00	24.594	40.841	14.500	51.990
3300.00	25.093	41.287	14.500	53.440
3400.00	25.575	41.720	14.500	54.890
3500.00	26.043	42.140	14.500	56.340
3600.00	26.496	42.548	14.500	57.790
3700.00	26.935	42.946	14.500	59.240
3800.00	27.361	43.332	14.500	60.690
3900.00	27.776	43.709	14.500	62.140
4000.00	28.179	44.076	14.500	63.590
4100.00	28.571	44.434	14.500	65.040
4200.00	28.953	44.784	14.500	66.490
4300.00	29.325	45.125	14.500	67.940
4400.00	29.688	45.458	14.500	69.390
4500.00	30.042	45.784	14.500	70.840
4600.00	30.387	46.103	14.500	72.290
4700.00	30.725	46.415	14.500	73.740
4800.00	31.055	46.720	14.500	75.190
4900.00	31.378	47.019	14.500	76.640
5000.00	31.694	47.312	14.500	78.090
5100.00	32.003	47.599	14.500	79.540
5200.00	32.305	47.880	14.500	80.990
5300.00	32.602	48.157	14.500	82.440
5400.00	32.892	48.428	14.500	83.890
5500.00	33.177	48.694	14.500	85.340
5600.00	33.457	48.955	14.500	86.790
5700.00	33.731	49.212	14.500	88.240
5800.00	34.000	49.464	14.500	89.690
5900.00	34.264	49.712	14.500	91.140
6000.00	34.524	49.955	14.500	92.590

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF WB/c

ΔH^{o}_{f298} = -13.5 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	7.470	7.470	8.378	0
300.00	7.470	7.522	8.437	.016
400.00	7.831	10.273	10.492	.977
500.00	8.571	12.728	11.434	2.078
600.00	9.445	14.861	11.938	3.249
700.00	10.355	16.726	12.236	4.459
800.00	11.256	18.373	12.424	5.693
900.00	12.130	19.844	12.547	6.942
1000.00	12.969	21.170	12.631	8.201
1100.00	13.770	22.377	12.689	9.467
1200.00	14.534	23.483	12.729	10.738
1300.00	15.262	24.503	12.756	12.013
1400.00	15.957	25.449	12.775	13.289
1500.00	16.619	26.331	12.787	14.567
1600.00	17.252	27.156	12.793	15.846
1700.00	17.858	27.932	12.796	17.126
1800.00	18.438	28.663	12.796	18.406
1900.00	18.995	29.358	12.894	19.690
2000.00	19.530	30.022	12.984	20.984
2100.00	20.044	30.657	13.074	22.287
2200.00	20.541	31.268	13.164	23.599
2300.00	21.020	31.855	13.255	24.920
2400.00	21.483	32.421	13.345	26.250
2500.00	21.932	32.967	13.435	27.589
2600.00	22.366	33.496	13.525	28.937
2700.00	22.788	34.008	13.615	30.294
2800.00	23.198	34.505	13.706	31.660
2900.00	23.596	34.988	13.796	33.035
3000.00	23.984	35.457	13.886	34.419
3100.00	24.361	35.914	13.976	35.812
3200.00	24.839	41.358	14.000	52.862
3300.00	25.346	41.789	14.000	54.262
3400.00	25.835	42.207	14.000	55.662
3500.00	26.309	42.613	14.000	57.062
3600.00	26.767	43.007	14.000	58.462
3700.00	27.212	43.391	14.000	59.862
3800.00	27.642	43.764	14.000	61.262
3900.00	28.060	44.128	14.000	62.662
4000.00	28.466	44.482	14.000	64.062
4100.00	28.861	44.828	14.000	65.462
4200.00	29.245	45.165	14.000	66.862
4300.00	29.620	45.494	14.000	68.262
4400.00	29.984	45.816	14.000	69.662
4500.00	30.339	46.131	14.000	71.062
4600.00	30.686	46.439	14.000	72.462
4700.00	31.024	46.740	14.000	73.862
4800.00	31.355	47.034	14.000	75.262
4900.00	31.678	47.323	14.000	76.662
5000.00	31.994	47.606	14.000	78.062
5100.00	32.302	47.883	14.000	79.462
5200.00	32.605	48.155	14.000	80.862
5300.00	32.901	48.422	14.000	82.262
5400.00	33.190	48.683	14.000	83.662
5500.00	33.474	48.940	14.000	85.062
5600.00	33.753	49.193	14.000	86.462
5700.00	34.026	49.440	14.000	87.862
5800.00	34.294	49.684	14.000	89.262
5900.00	34.557	49.923	14.000	90.662
6000.00	34.815	50.158	14.000	92.062

3.4 HAFNIUM SPECIES

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF Hf(g)

ΔH^{o}_{f298} = 145.5 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	44.645	44.645	4.972	0.000
300	44.645	44.675	4.973	0.009
400	44.840	46.110	5.010	0.508
500	45.211	47.237	5.114	1.013
600	45.629	48.184	5.285	1.533
700	46.055	49.015	5.500	2.072
800	46.472	49.764	5.734	2.634
900	46.877	50.453	5.970	3.219
1000	47.267	51.094	6.196	3.827
1100	47.642	51.695	6.407	4.458
1200	48.004	52.260	6.596	5.108
1300	48.352	52.795	6.763	5.776
1400	48.688	53.302	6.906	6.460
1500	49.011	53.782	7.026	7.157
1600	49.324	54.239	7.123	7.864
1700	49.626	54.673	7.201	8.581
1800	49.918	55.087	7.260	9.304
1900	50.200	55.481	7.305	10.032
2000	50.474	55.856	7.338	10.764
2100	50.739	56.215	7.361	11.499
2200	50.996	56.558	7.378	12.236
2300	51.245	56.886	7.391	12.975
2400	51.486	57.201	7.401	13.714
2500	51.721	57.503	7.411	14.455
2600	51.949	57.794	7.423	15.197
2700	52.171	58.074	7.436	15.940
2800	52.386	58.345	7.453	16.684
2900	52.596	58.607	7.474	17.430
3000	52.801	58.861	7.499	18.179
3100	53.000	59.107	7.530	18.930
3200	53.195	59.347	7.565	19.685
3300	53.385	59.580	7.606	20.444
3400	53.571	59.808	7.653	21.207
3500	53.752	60.030	7.704	21.974
3600	53.929	60.248	7.761	22.748
3700	54.103	60.462	7.822	23.527
3800	54.273	60.671	7.889	24.312
3900	54.440	60.877	7.959	25.105
4000	54.603	61.079	8.033	25.904
4100	54.764	61.279	8.111	26.711
4200	54.921	61.475	8.191	27.526
4300	55.076	61.669	8.275	28.350
4400	55.228	61.860	8.360	29.181
4500	55.377	62.049	8.448	30.022
4600	55.524	62.235	8.537	30.871
4700	55.669	62.420	8.627	31.729
4800	55.812	62.603	8.717	32.596
4900	55.952	62.783	8.808	33.473
5000	56.091	62.962	8.898	34.358
5100	56.227	63.139	8.988	35.252
5200	56.362	63.315	9.078	36.156
5300	56.494	63.488	9.166	37.068
5400	56.626	63.661	9.252	37.989
5500	56.755	63.831	9.337	38.918
5600	56.883	64.000	9.419	39.856
5700	57.009	64.167	9.500	40.802
5800	57.134	64.333	9.578	41.756
5900	57.258	64.498	9.653	42.717
6000	57.380	64.661	9.725	43.686

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF Hf/c

ΔH°_{f298} = 0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	10.666	10.666	6.225	0.000
300	10.666	10.705	6.226	0.012
400	10.907	12.504	6.345	0.639
500	11.377	13.936	6.466	1.280
600	11.906	15.127	6.583	1.932
700	12.442	16.151	6.701	2.596
800	12.963	17.054	6.815	3.272
900	13.464	17.863	6.925	3.959
1000	13.941	18.599	7.045	4.658
1100	14.396	19.276	7.164	5.368
1200	14.829	19.904	7.284	6.090
1300	15.242	20.492	7.399	6.825
1400	15.637	21.045	7.518	7.570
1500	16.015	21.568	7.640	8.328
1600	16.378	22.065	7.765	9.099
1700	16.727	22.539	7.885	9.881
1800	17.062	22.993	8.005	10.676
1900	17.386	23.429	8.126	11.482
2000	17.699	23.849	8.248	12.301
2100	18.027	25.066	8.378	14.782
2200	18.356	25.459	8.501	15.626
2300	18.673	25.840	8.623	16.482
2400	18.980	26.212	8.745	17.358
2500	19.280	28.769	8.000	23.721
2600	19.651	29.083	8.000	24.521
2700	20.006	29.385	8.000	25.321
2800	20.346	29.676	8.000	26.121
2900	20.673	29.956	8.000	26.921
3000	20.987	30.227	8.000	27.721
3100	21.289	30.490	8.000	28.521
3200	21.581	30.744	8.000	29.321
3300	21.862	30.990	8.000	30.121
3400	22.134	31.229	8.000	30.921
3500	22.397	31.461	8.000	31.721
3600	22.652	31.686	8.000	32.521
3700	22.899	31.905	8.000	33.321
3800	23.139	32.119	8.000	34.121
3900	23.372	32.326	8.000	34.921
4000	23.599	32.529	8.000	35.721
4100	23.819	32.727	8.000	36.521
4200	24.033	32.919	8.000	37.321
4300	24.242	33.108	8.000	38.121
4400	24.446	33.291	8.000	38.921
4500	24.644	33.471	8.000	39.721
4600	24.838	33.647	8.000	40.521
4700	25.027	33.819	8.000	41.321
4800	25.212	33.988	8.000	42.121
4900	25.393	34.152	8.000	42.921
5000	25.570	34.314	8.000	43.721
5100	25.743	34.473	8.000	44.521
5200	25.912	34.628	8.000	45.321
5300	26.078	34.780	8.000	46.121
5400	26.241	34.930	8.000	46.921
5500	26.400	35.074	8.000	47.721
5600	26.554	35.218	8.000	48.521
5700	26.707	35.360	8.000	49.321
5800	26.857	35.499	8.000	50.121
5900	27.005	35.636	8.000	50.921
6000	27.150	35.770	8.000	51.721

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfO(g)

ΔH^{o}_{f298} = 30.0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	T (°K)
298.15	56.357	56.357	7.462	0
300.00	56.357	56.403	7.470	.014
400.00	56.655	58.606	7.869	.780
500.00	57.229	60.390	8.131	1.580
600.00	57.884	61.890	8.328	2.434
700.00	58.551	63.185	8.465	3.264
800.00	59.203	64.322	8.564	4.096
900.00	59.829	65.335	8.635	4.956
1000.00	60.426	66.248	8.689	5.822
1100.00	60.994	67.078	8.730	6.693
1200.00	61.533	67.839	8.762	7.558
1300.00	62.045	68.542	8.788	8.445
1400.00	62.533	69.194	8.808	9.325
1500.00	62.997	69.802	8.825	10.207
1600.00	63.441	70.372	8.839	11.090
1700.00	63.864	70.908	8.850	11.974
1800.00	64.270	71.414	8.860	12.860
1900.00	64.659	71.893	8.868	13.746
2000.00	65.032	72.348	8.875	14.633
2100.00	65.391	72.782	8.881	15.521
2200.00	65.736	73.195	8.887	16.410
2300.00	66.069	73.590	8.891	17.299
2400.00	66.390	73.969	8.895	18.188
2500.00	66.701	74.332	8.899	19.078
2600.00	67.001	74.681	8.902	19.968
2700.00	67.292	75.017	8.905	20.858
2800.00	67.573	75.341	8.908	21.749
2900.00	67.847	75.653	8.910	22.640
3000.00	68.112	75.955	8.912	23.531
3100.00	68.370	76.248	8.914	24.422
3200.00	68.620	76.531	8.916	25.314
3300.00	68.864	76.805	8.917	26.205
3400.00	69.102	77.071	8.919	27.097
3500.00	69.333	77.330	8.920	27.989
3600.00	69.559	77.581	8.921	28.881
3700.00	69.779	77.826	8.922	29.773
3800.00	69.994	78.064	8.923	30.656
3900.00	70.204	78.295	8.924	31.558
4000.00	70.409	78.521	8.925	32.450
4100.00	70.609	78.742	8.926	33.343
4200.00	70.806	78.957	8.927	34.236
4300.00	70.998	79.167	8.928	35.128
4400.00	71.186	79.372	8.928	36.021
4500.00	71.370	79.573	8.929	36.914
4600.00	71.550	79.769	8.929	37.807
4700.00	71.727	79.961	8.930	38.700
4800.00	71.901	80.149	8.931	39.593
4900.00	72.071	80.333	8.931	40.486
5000.00	72.238	80.514	8.931	41.379
5100.00	72.402	80.691	8.932	42.272
5200.00	72.563	80.864	8.932	43.156
5300.00	72.721	81.034	8.933	44.059
5400.00	72.877	81.201	8.933	44.952
5500.00	73.030	81.365	8.933	45.845
5600.00	73.180	81.526	8.934	46.739
5700.00	73.328	81.684	8.934	47.632
5800.00	73.473	81.840	8.934	48.526
5900.00	73.616	81.992	8.935	49.419
6000.00	73.757	82.142	8.935	50.312

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $HfO_2(g)$

ΔH°_{f298} = - 85 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	60.453	60.453	11.511	0
300.00	60.453	60.524	11.532	.021
400.00	60.917	63.977	12.465	1.224
500.00	61.823	66.832	13.115	2.535
600.00	62.866	69.265	13.557	3.940
700.00	63.934	71.379	13.863	5.212
800.00	64.984	73.245	14.079	6.639
900.00	65.996	74.913	14.236	8.026
1000.00	66.964	76.420	14.354	9.435
1100.00	67.887	77.792	14.443	10.895
1200.00	68.766	79.052	14.513	12.343
1300.00	69.602	80.216	14.568	13.798
1400.00	70.399	81.297	14.613	15.257
1500.00	71.160	82.307	14.649	16.720
1600.00	71.887	83.253	14.679	18.186
1700.00	72.582	84.144	14.704	19.655
1800.00	73.247	84.985	14.725	21.127
1900.00	73.886	85.781	14.743	22.630
2000.00	74.500	86.538	14.758	24.075
2100.00	75.091	87.258	14.772	25.552
2200.00	75.660	87.946	14.783	27.030
2300.00	76.208	88.603	14.793	28.509
2400.00	76.738	89.233	14.802	29.988
2500.00	77.250	89.837	14.810	31.469
2600.00	77.745	90.418	14.817	32.950
2700.00	78.225	90.978	14.823	34.432
2800.00	78.690	91.517	14.829	35.915
2900.00	79.141	92.037	14.834	37.398
3000.00	79.580	92.540	14.839	38.882
3100.00	80.006	93.027	14.843	40.366
3200.00	80.420	93.498	14.846	41.850
3300.00	80.823	93.955	14.850	43.335
3400.00	81.216	94.398	14.853	44.820
3500.00	81.599	94.829	14.856	46.306
3600.00	81.972	95.248	14.858	47.791
3700.00	82.336	95.655	14.861	49.277
3800.00	82.692	96.051	14.863	50.764
3900.00	83.040	96.437	14.865	52.250
4000.00	83.379	96.814	14.867	53.737
4100.00	83.712	97.181	14.869	55.223
4200.00	84.036	97.539	14.870	56.710
4300.00	84.355	97.889	14.872	58.197
4400.00	84.666	98.231	14.873	59.685
4500.00	84.971	98.565	14.875	61.172
4600.00	85.270	98.892	14.876	62.660
4700.00	85.564	99.212	14.877	64.147
4800.00	85.851	99.525	14.878	65.635
4900.00	86.133	99.832	14.879	67.123
5000.00	86.410	100.133	14.880	68.611
5100.00	86.682	100.427	14.881	70.099
5200.00	86.949	100.716	14.882	71.587
5300.00	87.212	101.000	14.883	73.076
5400.00	87.470	101.278	14.884	74.564
5500.00	87.723	101.551	14.884	76.052
5600.00	87.973	101.819	14.885	77.541
5700.00	88.218	102.083	14.886	79.029
5800.00	88.459	102.342	14.886	80.518
5900.00	88.697	102.596	14.887	82.007
6000.00	88.930	102.846	14.888	83.495

THERMODYNAMIC FUNCTIONS OF HfO_2/c

ΔH°_{f298} = -266.1 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	14.180	14.180	14.095	0
300.00	14.180	14.267	14.147	.026
400.00	14.762	18.632	16.047	1.548
500.00	15.916	22.329	17.038	3.207
600.00	17.255	25.495	17.671	4.944
700.00	18.634	28.256	18.136	6.735
800.00	19.992	30.703	18.510	8.568
900.00	21.307	32.902	18.832	10.436
1000.00	22.568	34.901	19.122	12.334
1100.00	23.773	36.736	19.390	14.259
1200.00	24.925	38.435	19.644	16.211
1300.00	26.026	40.017	19.888	18.188
1400.00	27.079	41.499	20.124	20.188
1500.00	28.087	42.895	20.355	22.213
1600.00	29.054	44.216	20.582	24.259
1700.00	29.983	45.471	20.806	26.329
1800.00	30.877	46.666	21.027	28.420
1900.00	31.739	47.809	21.246	30.534
2000.00	32.570	48.904	21.463	32.670
2100.00	33.373	49.957	21.679	34.827
2200.00	34.150	50.970	21.800	37.005
2300.00	34.902	51.939	21.800	39.185
2400.00	35.632	52.867	21.800	41.365
2500.00	36.339	53.757	21.800	43.545
2600.00	37.025	54.612	21.800	45.725
2700.00	37.692	55.435	21.800	47.905
2800.00	38.340	56.228	21.800	50.085
2900.00	38.970	56.993	21.800	52.265
3000.00	39.583	57.732	21.800	54.445
3100.00	40.180	58.446	21.800	56.625
3200.00	40.818	65.132	21.800	77.805
3300.00	41.565	65.803	21.800	79.985
3400.00	42.288	66.454	21.800	82.165
3500.00	42.987	67.086	21.800	84.345
3600.00	43.665	67.700	21.800	86.525
3700.00	44.323	68.297	21.800	88.705
3800.00	44.961	68.879	21.800	90.885
3900.00	45.582	69.445	21.800	93.065
4000.00	46.186	69.997	21.800	95.245
4100.00	46.773	70.535	21.800	97.425
4200.00	47.345	71.060	21.800	99.605
4300.00	47.902	71.573	21.800	101.785
4400.00	48.446	72.075	21.800	103.965
4500.00	48.977	72.564	21.800	106.145
4600.00	49.495	73.044	21.800	108.325
4700.00	50.001	73.512	21.800	110.505
4800.00	50.495	73.971	21.800	112.685
4900.00	50.979	74.421	21.800	114.865
5000.00	51.452	74.861	21.800	117.045
5100.00	51.916	75.293	21.800	119.225
5200.00	52.369	75.716	21.800	121.405
5300.00	52.814	76.132	21.800	123.585
5400.00	53.249	76.539	21.800	125.765
5500.00	53.676	76.939	21.800	127.945
5600.00	54.095	77.332	21.800	130.125
5700.00	54.506	77.718	21.800	132.305
5800.00	54.910	78.097	21.800	134.485
5900.00	55.306	78.470	21.800	136.665
6000.00	55.695	78.836	21.800	138.845

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfCl(g)

ΔH°_{f298} = -3 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	61.740	61.740	8.464	0
300.00	61.740	61.793	8.469	.016
400.00	62.075	64.258	8.657	.873
500.00	62.713	66.201	8.754	1.744
600.00	63.432	67.802	8.809	2.623
700.00	64.156	69.163	8.843	3.505
800.00	64.857	70.346	8.866	4.391
900.00	65.526	71.391	8.882	5.276
1000.00	66.160	72.327	8.893	6.167
1100.00	66.760	73.175	8.902	7.057
1200.00	67.327	73.950	8.908	7.947
1300.00	67.865	74.663	8.913	8.838
1400.00	68.374	75.324	8.917	9.730
1500.00	68.858	75.939	8.920	10.622
1600.00	69.319	76.515	8.923	11.514
1700.00	69.758	77.056	8.925	12.406
1800.00	70.178	77.566	8.927	13.299
1900.00	70.580	78.049	8.929	14.192
2000.00	70.965	78.507	8.930	15.085
2100.00	71.334	78.943	8.931	15.978
2200.00	71.690	79.358	8.932	16.871
2300.00	72.032	79.755	8.933	17.764
2400.00	72.361	80.135	8.934	18.657
2500.00	72.680	80.500	8.934	19.551
2600.00	72.987	80.851	8.935	20.444
2700.00	73.285	81.188	8.936	21.338
2800.00	73.573	81.513	8.936	22.231
2900.00	73.852	81.826	8.936	23.125
3000.00	74.123	82.129	8.937	24.019
3100.00	74.386	82.422	8.937	24.912
3200.00	74.642	82.706	8.938	25.806
3300.00	74.890	82.981	8.938	26.700
3400.00	75.132	83.248	8.938	27.594
3500.00	75.368	83.507	8.938	28.488
3600.00	75.597	83.759	8.939	29.381
3700.00	75.821	84.004	8.939	30.275
3800.00	76.040	84.242	8.939	31.169
3900.00	76.253	84.474	8.939	32.063
4000.00	76.461	84.701	8.939	32.957
4100.00	76.665	84.921	8.939	33.851
4200.00	76.864	85.137	8.940	34.745
4300.00	77.059	85.347	8.940	35.639
4400.00	77.250	85.553	8.940	36.533
4500.00	77.436	85.754	8.940	37.427
4600.00	77.619	85.950	8.940	38.321
4700.00	77.799	86.142	8.940	39.215
4800.00	77.975	86.331	8.940	40.109
4900.00	78.147	86.515	8.940	41.003
5000.00	78.316	86.695	8.940	41.897
5100.00	78.482	86.873	8.940	42.791
5200.00	78.645	87.046	8.941	43.685
5300.00	78.805	87.216	8.941	44.579
5400.00	78.963	87.384	8.941	45.473
5500.00	79.117	87.548	8.941	46.367
5600.00	79.269	87.709	8.941	47.261
5700.00	79.419	87.867	8.941	48.155
5800.00	79.566	88.022	8.941	49.049
5900.00	79.710	88.175	8.941	49.943
6000.00	79.853	88.326	8.941	50.838

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $HfCl_2(g)$

ΔH^{o}_{f298} = -86 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	70.140	70.140	13.905	0
300.00	70.141	70.226	13.915	.026
400.00	70.692	74.290	14.310	1.439
500.00	71.745	77.507	14.511	2.881
600.00	72.933	80.164	14.626	4.339
700.00	74.131	82.425	14.698	5.805
800.00	75.294	84.591	14.745	7.276
900.00	76.403	86.129	14.778	8.754
1000.00	77.455	87.687	14.801	10.235
1100.00	78.450	89.099	14.819	11.714
1200.00	79.392	90.389	14.832	13.197
1300.00	80.284	91.577	14.843	14.680
1400.00	81.131	92.677	14.851	16.165
1500.00	81.935	93.702	14.858	17.651
1600.00	82.701	94.661	14.864	19.137
1700.00	83.431	95.562	14.868	20.623
1800.00	84.125	96.412	14.872	22.110
1900.00	84.787	97.216	14.875	23.598
2000.00	85.417	97.979	14.878	25.085
2100.00	86.051	98.705	14.880	26.575
2200.00	86.643	99.398	14.883	28.061
2300.00	87.212	100.059	14.884	29.550
2400.00	87.760	100.693	14.886	31.038
2500.00	88.290	101.300	14.887	32.527
2600.00	88.801	101.884	14.889	34.016
2700.00	89.296	102.446	14.890	35.505
2800.00	89.776	102.988	14.891	36.994
2900.00	90.240	103.510	14.892	38.483
3000.00	90.691	104.015	14.892	39.972
3100.00	91.129	104.504	14.893	41.461
3200.00	91.554	104.976	14.894	42.951
3300.00	91.968	105.435	14.894	44.440
3400.00	92.371	105.879	14.895	45.929
3500.00	92.763	106.311	14.896	47.419
3600.00	93.145	106.731	14.896	48.909
3700.00	93.518	107.139	14.896	50.398
3800.00	93.881	107.536	14.897	51.888
3900.00	94.237	107.925	14.897	53.378
4000.00	94.585	108.300	14.898	54.867
4100.00	94.923	108.668	14.898	56.357
4200.00	95.254	109.027	14.898	57.847
4300.00	95.578	109.378	14.898	59.337
4400.00	95.896	109.720	14.899	60.827
4500.00	96.207	110.055	14.899	62.316
4600.00	96.512	110.383	14.899	63.806
4700.00	96.810	110.703	14.899	65.296
4800.00	97.103	111.017	14.899	66.786
4900.00	97.390	111.324	14.900	68.276
5000.00	97.672	111.625	14.900	69.766
5100.00	97.948	111.920	14.900	71.256
5200.00	98.220	112.209	14.900	72.746
5300.00	98.486	112.493	14.900	74.236
5400.00	98.748	112.772	14.900	75.726
5500.00	99.006	113.045	14.901	77.216
5600.00	99.259	113.313	14.901	78.706
5700.00	99.508	113.577	14.901	80.196
5800.00	99.752	113.836	14.901	81.686
5900.00	99.993	114.091	14.901	83.177
6000.00	100.230	114.342	14.901	84.667

THERMODYNAMIC FUNCTIONS OF $HfCl_3(g)$

ΔH^{o}_{f298} = -159 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	85.916	85.916	18.377	0
300.00	85.917	86.030	18.393	.034
400.00	86.646	91.412	18.983	1.906
500.00	88.041	95.654	19.284	3.821
600.00	89.618	99.216	19.457	5.759
700.00	91.209	102.224	19.564	7.710
800.00	92.753	104.841	19.634	9.671
900.00	94.228	107.157	19.683	11.637
1000.00	95.626	109.233	19.719	13.607
1100.00	96.950	111.113	19.745	15.580
1200.00	98.203	112.832	19.765	17.556
1300.00	99.390	114.415	19.781	19.533
1400.00	100.516	115.881	19.793	21.512
1500.00	101.586	117.247	19.803	23.491
1600.00	102.606	118.526	19.812	25.472
1700.00	103.578	119.727	19.818	27.454
1800.00	104.507	120.860	19.824	29.436
1900.00	105.396	121.932	19.829	31.418
2000.00	106.248	122.949	19.833	33.402
2100.00	107.067	123.917	19.837	35.385
2200.00	107.854	124.840	19.840	37.369
2300.00	108.612	125.722	19.843	39.353
2400.00	109.342	126.566	19.845	41.337
2500.00	110.047	127.376	19.847	43.322
2600.00	110.729	128.155	19.849	45.307
2700.00	111.388	128.904	19.851	47.292
2800.00	112.027	129.626	19.852	49.277
2900.00	112.646	130.322	19.854	51.262
3000.00	113.246	130.996	19.855	53.248
3100.00	113.829	131.647	19.856	55.233
3200.00	114.396	132.277	19.857	57.219
3300.00	114.947	132.888	19.858	59.205
3400.00	115.484	133.481	19.859	61.190
3500.00	116.006	134.057	19.859	63.176
3600.00	116.515	134.616	19.860	65.162
3700.00	117.012	135.160	19.861	67.148
3800.00	117.497	135.690	19.861	69.134
3900.00	117.970	136.206	19.862	71.121
4000.00	118.432	136.709	19.862	73.107
4100.00	118.884	137.199	19.863	75.093
4200.00	119.325	137.678	19.863	77.079
4300.00	119.758	138.145	19.864	79.066
4400.00	120.181	138.602	19.864	81.052
4500.00	120.595	139.048	19.864	83.038
4600.00	121.001	139.485	19.865	85.025
4700.00	121.399	139.912	19.865	87.011
4800.00	121.789	140.330	19.865	88.998
4900.00	122.172	140.740	19.866	90.984
5000.00	122.547	141.141	19.866	92.971
5100.00	122.915	141.534	19.866	94.958
5200.00	123.277	141.920	19.866	96.944
5300.00	123.632	142.299	19.866	98.931
5400.00	123.982	142.670	19.867	100.917
5500.00	124.325	143.035	19.867	102.904
5600.00	124.662	143.393	19.867	104.891
5700.00	124.994	143.744	19.867	106.876
5800.00	125.320	144.090	19.867	108.864
5900.00	125.641	144.429	19.868	110.851
6000.00	125.957	144.763	19.868	112.838

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $HfCl_4(g)$

ΔH^o_{f298} = -213.0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	91.017	91.017	25.753	0
300.00	91.017	91.164	25.775	.044
400.00	91.961	98.131	24.599	2.468
500.00	93.768	103.670	25.019	4.951
600.00	95.411	108.254	25.258	7.466
700.00	97.875	112.160	25.407	9.999
800.00	99.877	115.559	25.505	12.545
900.00	101.790	118.567	25.572	15.099
1000.00	103.605	121.264	25.621	17.659
1100.00	105.323	123.708	25.658	20.223
1200.00	106.950	125.942	25.686	22.790
1300.00	108.491	127.998	25.707	25.360
1400.00	109.953	129.904	25.725	27.932
1500.00	111.343	131.679	25.739	30.505
1600.00	112.666	133.341	25.750	33.079
1700.00	113.929	134.902	25.759	35.655
1800.00	115.135	136.375	25.767	38.231
1900.00	116.290	137.768	25.774	40.808
2000.00	117.397	139.090	25.780	43.386
2100.00	118.461	140.348	25.785	45.964
2200.00	119.483	141.548	25.789	48.543
2300.00	120.467	142.694	25.793	51.122
2400.00	121.417	143.792	25.796	53.702
2500.00	122.333	144.845	25.799	56.281
2600.00	123.218	145.857	25.802	58.861
2700.00	124.075	146.831	25.804	61.442
2800.00	124.904	147.770	25.806	64.022
2900.00	125.709	148.675	25.808	66.603
3000.00	126.489	149.550	25.810	69.184
3100.00	127.246	150.396	25.811	71.765
3200.00	127.983	151.215	25.813	74.346
3300.00	128.699	152.010	25.814	76.927
3400.00	129.396	152.781	25.815	79.509
3500.00	130.075	153.529	25.816	82.090
3600.00	130.736	154.256	25.817	84.672
3700.00	131.382	154.964	25.818	87.254
3800.00	132.011	155.652	25.819	89.836
3900.00	132.626	156.323	25.819	92.418
4000.00	133.227	156.977	25.820	94.999
4100.00	133.814	157.614	25.821	97.582
4200.00	134.388	158.236	25.821	100.164
4300.00	134.950	158.844	25.822	102.746
4400.00	135.500	159.438	25.822	105.328
4500.00	136.038	160.018	25.823	107.910
4600.00	136.565	160.586	25.823	110.493
4700.00	137.082	161.141	25.824	113.075
4800.00	137.589	161.685	25.824	115.657
4900.00	138.087	162.217	25.825	118.240
5000.00	138.574	162.739	25.825	120.822
5100.00	139.053	163.250	25.825	123.405
5200.00	139.523	163.752	25.826	125.987
5300.00	139.985	164.244	25.826	128.570
5400.00	140.439	164.726	25.826	131.153
5500.00	140.885	165.200	25.826	133.735
5600.00	141.323	165.666	25.827	136.318
5700.00	141.754	166.123	25.827	138.901
5800.00	142.178	166.572	25.827	141.485
5900.00	142.595	167.013	25.827	144.066
6000.00	143.006	167.448	25.828	146.649

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $HfCl_4/c$

ΔH^{o}_{f298} = - 236.88 KCAL/MOLE

T (^{o}K)	$-(F-H_{298})/T$ (cal/mole ^{o}K)	S (cal/mole ^{o}K)	C_p (cal/mole ^{o}K)	H^{T}_{298} (kcal/mole)
TEMP	F-T	S	CP	H
298.15	45.600	45.600	28.793	0.
300.00	45.601	45.778	28.826	0.053
400.00	46.748	54.253	29.982	3.002
500.00	48.948	61.008	30.518	6.030
600.00	51.437	66.600	30.809	9.098
700.00	53.952	71.363	30.984	12.188
800.00	58.201	91.054	36.200	26.282
900.00	62.093	95.317	36.200	29.902
1000.00	65.610	99.131	36.200	33.522
1100.00	68.816	102.582	36.200	37.142
1200.00	71.763	105.731	36.200	40.762
1300.00	74.489	108.629	36.200	44.382
1400.00	77.025	111.312	36.200	48.002
1500.00	79.395	113.809	36.200	51.622
1600.00	81.619	116.146	36.200	55.242
1700.00	83.716	118.340	36.200	58.862
1800.00	85.697	120.409	36.200	62.482
1900.00	87.576	122.367	36.200	66.102
2000.00	89.362	124.223	36.200	69.722
2100.00	91.065	125.990	36.200	73.342
2200.00	92.691	127.674	36.200	76.962
2300.00	94.247	129.283	36.200	80.582
2400.00	95.739	130.823	36.200	84.202
2500.00	97.172	132.301	36.200	87.822
2600.00	98.551	133.721	36.200	91.442
2700.00	99.879	135.087	36.200	95.062
2800.00	101.160	136.404	36.200	98.682
2900.00	102.397	137.674	36.200	102.302
3000.00	103.594	138.901	36.200	105.922
3100.00	104.752	140.089	36.200	109.542
3200.00	105.874	141.238	36.200	113.162
3300.00	106.963	142.351	36.200	116.782
3400.00	108.020	143.432	36.200	120.402
3500.00	109.047	144.481	36.200	124.022
3600.00	110.045	145.501	36.200	127.642
3700.00	111.017	146.493	36.200	131.262
3800.00	111.963	147.458	36.200	134.882
3900.00	112.885	148.399	36.200	138.502
4000.00	113.785	149.315	36.200	142.122
4100.00	114.662	150.209	36.200	145.742
4200.00	115.519	151.082	36.200	149.362
4300.00	116.356	151.933	36.200	152.982
4400.00	117.174	152.766	36.200	156.602
4500.00	117.974	153.579	36.200	160.222
4600.00	118.757	154.375	36.200	163.842
4700.00	119.523	155.153	36.200	167.462
4800.00	120.273	155.915	36.200	171.082
4900.00	121.008	156.662	36.200	174.702
5000.00	121.729	157.393	36.200	178.322
5100.00	122.435	158.110	36.200	181.942
5200.00	123.128	158.813	36.200	185.562
5300.00	123.808	159.502	36.200	189.182
5400.00	124.475	160.179	36.200	192.802
5500.00	125.130	160.843	36.200	196.422
5600.00	125.774	161.496	36.200	200.042
5700.00	126.406	162.136	36.200	203.662
5800.00	127.028	162.766	36.200	207.282
5900.00	127.639	163.385	36.200	210.902
6000.00	128.239	163.993	36.200	214.522

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfF(g)

ΔH°_{f298} = -21 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	59.305	59.305	7.916	0
300.00	59.305	59.354	7.924	.015
400.00	59.620	61.684	8.266	.826
500.00	60.226	63.553	8.472	1.663
600.00	60.914	65.110	8.600	2.517
700.00	61.611	66.442	8.684	3.382
800.00	62.289	67.606	8.740	4.253
900.00	62.938	68.637	8.781	5.129
1000.00	63.555	69.564	8.810	6.009
1100.00	64.140	70.405	8.832	6.891
1200.00	64.695	71.174	8.849	7.775
1300.00	65.221	71.883	8.863	8.661
1400.00	65.720	72.540	8.874	9.548
1500.00	66.196	73.153	8.882	10.436
1600.00	66.649	73.726	8.889	11.324
1700.00	67.081	74.265	8.895	12.213
1800.00	67.494	74.774	8.900	13.103
1900.00	67.890	75.255	8.905	13.994
2000.00	68.270	75.712	8.908	14.884
2100.00	68.635	76.147	8.911	15.775
2200.00	68.986	76.561	8.914	16.666
2300.00	69.324	76.958	8.917	17.558
2400.00	69.650	77.337	8.919	18.450
2500.00	69.965	77.701	8.920	19.342
2600.00	70.269	78.051	8.922	20.234
2700.00	70.564	78.388	8.924	21.126
2800.00	70.849	78.713	8.925	22.019
2900.00	71.125	79.026	8.926	22.911
3000.00	71.394	79.328	8.927	23.804
3100.00	71.655	79.621	8.928	24.697
3200.00	71.908	79.905	8.929	25.589
3300.00	72.154	80.179	8.930	26.482
3400.00	72.394	80.446	8.931	27.375
3500.00	72.628	80.705	8.931	28.268
3600.00	72.856	80.957	8.932	29.162
3700.00	73.078	81.201	8.932	30.055
3800.00	73.295	81.439	8.933	30.948
3900.00	73.507	81.671	8.933	31.841
4000.00	73.714	81.898	8.934	32.735
4100.00	73.916	82.118	8.934	33.628
4200.00	74.114	82.334	8.935	34.522
4300.00	74.308	82.544	8.935	35.415
4400.00	74.497	82.749	8.935	36.309
4500.00	74.683	82.950	8.936	37.202
4600.00	74.865	83.146	8.936	38.096
4700.00	75.043	83.339	8.936	38.989
4800.00	75.218	83.527	8.936	39.883
4900.00	75.389	83.711	8.937	40.777
5000.00	75.557	83.892	8.937	41.670
5100.00	75.723	84.069	8.937	42.564
5200.00	75.885	84.242	8.937	43.458
5300.00	76.044	84.412	8.938	44.351
5400.00	76.201	84.579	8.938	45.245
5500.00	76.354	84.743	8.938	46.139
5600.00	76.506	84.904	8.938	47.033
5700.00	76.654	85.063	8.938	47.927
5800.00	76.801	85.218	8.938	48.820
5900.00	76.945	85.371	8.938	49.714
6000.00	77.086	85.521	8.939	50.608

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $NfF_2(g)$

ΔH°_{f298} = -143 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	65.245	65.245	12.758	0
300.00	65.245	65.324	12.775	.024
400.00	65.756	69.107	13.499	1.340
500.00	66.742	72.169	13.929	2.714
600.00	67.866	74.734	14.195	4.121
700.00	69.008	76.936	14.368	5.550
800.00	70.122	78.863	14.486	6.993
900.00	71.190	80.574	14.570	8.446
1000.00	72.207	82.113	14.631	9.906
1100.00	73.172	83.510	14.677	11.371
1200.00	74.087	84.788	14.712	12.841
1300.00	74.956	85.967	14.740	14.314
1400.00	75.782	87.060	14.762	15.789
1500.00	76.569	88.079	14.780	17.266
1600.00	77.318	89.033	14.795	18.744
1700.00	78.034	89.931	14.807	20.225
1800.00	78.719	90.777	14.817	21.706
1900.00	79.375	91.579	14.826	23.188
2000.00	80.004	92.339	14.834	24.671
2100.00	80.609	93.063	14.840	26.155
2200.00	81.191	93.754	14.846	27.639
2300.00	81.751	94.414	14.851	29.124
2400.00	82.292	95.046	14.855	30.609
2500.00	82.815	95.652	14.859	32.095
2600.00	83.320	96.235	14.862	33.581
2700.00	83.808	96.796	14.865	35.067
2800.00	84.282	97.337	14.868	36.554
2900.00	84.741	97.859	14.870	38.041
3000.00	85.187	98.363	14.873	39.528
3100.00	85.620	98.850	14.875	41.015
3200.00	86.041	99.323	14.876	42.503
3300.00	86.450	99.781	14.878	43.990
3400.00	86.849	100.225	14.879	45.478
3500.00	87.237	100.656	14.881	46.966
3600.00	87.616	101.075	14.882	48.455
3700.00	87.985	101.483	14.883	49.943
3800.00	88.345	101.880	14.884	51.431
3900.00	88.697	102.267	14.885	52.920
4000.00	89.041	102.643	14.886	54.408
4100.00	89.378	103.011	14.887	55.897
4200.00	89.707	103.370	14.888	57.386
4300.00	90.028	103.720	14.889	58.875
4400.00	90.343	104.062	14.889	60.363
4500.00	90.652	104.397	14.890	61.852
4600.00	90.954	104.724	14.891	63.341
4700.00	91.251	105.045	14.891	64.830
4800.00	91.541	105.358	14.892	66.320
4900.00	91.827	105.665	14.892	67.809
5000.00	92.106	105.966	14.893	69.298
5100.00	92.381	106.261	14.893	70.787
5200.00	92.651	106.550	14.893	72.277
5300.00	92.916	106.834	14.894	73.766
5400.00	93.176	107.112	14.894	75.255
5500.00	93.432	107.386	14.895	76.745
5600.00	93.683	107.654	14.895	78.234
5700.00	93.931	107.918	14.895	79.724
5800.00	94.174	108.177	14.896	81.213
5900.00	94.414	108.431	14.896	82.703
6000.00	94.649	108.682	14.896	84.193

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $HfF_3(g)$

ΔH°_{f298} = -280 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	77.011	77.011	16.575	0
300.00	77.011	77.113	16.602	.031
400.00	77.677	82.057	17.720	1.752
500.00	78.969	86.048	18.381	3.560
600.00	80.446	89.476	18.789	5.420
700.00	81.949	92.396	19.054	7.313
800.00	83.418	94.953	19.234	9.228
900.00	84.826	97.226	19.362	11.158
1000.00	86.172	99.271	19.455	13.099
1100.00	87.448	101.128	19.525	15.048
1200.00	88.660	102.830	19.579	17.003
1300.00	89.811	104.399	19.621	18.963
1400.00	90.906	105.854	19.655	20.927
1500.00	91.948	107.211	19.682	22.894
1600.00	92.942	108.482	19.705	24.864
1700.00	93.892	109.677	19.724	26.835
1800.00	94.800	110.805	19.740	28.808
1900.00	95.671	111.873	19.753	30.783
2000.00	96.507	112.886	19.765	32.759
2100.00	97.310	113.851	19.774	34.736
2200.00	98.083	114.771	19.783	36.714
2300.00	98.828	115.650	19.791	38.692
2400.00	99.546	116.493	19.797	40.672
2500.00	100.240	117.301	19.803	42.652
2600.00	100.912	118.078	19.808	44.632
2700.00	101.561	118.825	19.813	46.613
2800.00	102.191	119.546	19.817	48.595
2900.00	102.801	120.242	19.821	50.577
3000.00	103.394	120.914	19.824	52.559
3100.00	103.970	121.564	19.827	54.541
3200.00	104.529	122.193	19.830	56.524
3300.00	105.074	122.803	19.832	58.507
3400.00	105.604	123.395	19.835	60.491
3500.00	106.121	123.970	19.837	62.474
3600.00	106.624	124.529	19.839	64.458
3700.00	107.116	125.073	19.840	66.442
3800.00	107.595	125.602	19.842	68.426
3900.00	108.063	126.117	19.844	70.410
4000.00	108.521	126.620	19.845	72.395
4100.00	108.968	127.110	19.846	74.379
4200.00	109.406	127.588	19.847	76.364
4300.00	109.834	128.055	19.849	78.349
4400.00	110.254	128.511	19.850	80.334
4500.00	110.664	128.958	19.851	82.319
4600.00	111.067	129.394	19.852	84.304
4700.00	111.461	129.821	19.852	86.289
4800.00	111.848	130.239	19.853	88.274
4900.00	112.228	130.648	19.854	90.260
5000.00	112.600	131.049	19.855	92.245
5100.00	112.966	131.442	19.855	94.231
5200.00	113.325	131.828	19.856	96.216
5300.00	113.677	132.206	19.857	98.202
5400.00	114.024	132.577	19.857	100.188
5500.00	114.365	132.942	19.858	102.173
5600.00	114.700	133.299	19.858	104.159
5700.00	115.029	133.651	19.859	106.145
5800.00	115.353	133.996	19.859	108.131
5900.00	115.672	134.336	19.860	110.117
6000.00	115.986	134.670	19.860	112.103

THERMODYNAMIC FUNCTIONS OF HfF_4(g)

ΔH°_{f298} = -410.0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	81.719	81.719	21.526	0
300.00	81.719	81.852	21.562	.040
400.00	82.586	88.279	23.048	2.277
500.00	84.265	93.523	23.914	4.629
600.00	86.185	97.933	24.443	7.049
700.00	88.141	101.729	24.785	9.511
800.00	90.051	105.054	25.017	12.002
900.00	91.866	108.011	25.181	14.513
1000.00	93.633	110.670	25.300	17.037
1100.00	95.294	113.086	25.390	19.572
1200.00	96.870	115.298	25.459	22.114
1300.00	98.367	117.338	25.513	24.663
1400.00	99.790	119.231	25.557	27.217
1500.00	101.146	120.995	25.592	29.774
1600.00	102.439	122.646	25.621	32.335
1700.00	103.674	124.202	25.645	34.898
1800.00	104.855	125.668	25.665	37.463
1900.00	105.987	127.056	25.682	40.031
2000.00	107.074	128.374	25.697	42.600
2100.00	108.118	129.628	25.709	45.170
2200.00	109.124	130.824	25.720	47.742
2300.00	110.092	131.966	25.730	50.314
2400.00	111.027	133.063	25.738	52.887
2500.00	111.929	134.114	25.746	55.462
2600.00	112.802	135.124	25.752	58.037
2700.00	113.647	136.096	25.758	60.612
2800.00	114.465	137.033	25.763	63.188
2900.00	115.259	137.937	25.768	65.765
3000.00	116.030	138.810	25.772	68.342
3100.00	116.778	139.655	25.776	70.919
3200.00	117.506	140.474	25.780	73.497
3300.00	118.214	141.267	25.783	76.075
3400.00	118.904	142.037	25.786	78.654
3500.00	119.575	142.784	25.789	81.232
3600.00	120.230	143.511	25.791	83.811
3700.00	120.869	144.218	25.793	86.390
3800.00	121.492	144.906	25.795	88.970
3900.00	122.101	145.576	25.797	91.550
4000.00	122.696	146.229	25.799	94.129
4100.00	123.278	146.866	25.801	96.709
4200.00	123.847	147.486	25.802	99.289
4300.00	124.404	148.095	25.804	101.870
4400.00	124.949	148.688	25.805	104.450
4500.00	125.483	149.268	25.806	107.031
4600.00	126.006	149.835	25.807	109.611
4700.00	126.519	150.390	25.809	112.192
4800.00	127.022	150.933	25.810	114.773
4900.00	127.516	151.466	25.811	117.354
5000.00	128.000	151.987	25.811	119.935
5100.00	128.475	152.498	25.812	122.516
5200.00	128.942	152.999	25.813	125.098
5300.00	129.401	153.491	25.814	127.679
5400.00	129.851	153.974	25.815	130.261
5500.00	130.294	154.447	25.815	132.842
5600.00	130.730	154.913	25.816	135.424
5700.00	131.158	155.369	25.817	138.005
5800.00	131.579	155.818	25.817	140.587
5900.00	131.994	156.260	25.818	143.169
6000.00	132.402	156.694	25.818	145.750

THERMODYNAMIC FUNCTIONS OF HfF_4/c

ΔH^{o}_{f298} = -461.4 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	31.500	31.500	25.401	0
300.00	31.500	31.657	25.423	.047
400.00	32.511	39.127	26.553	2.646
500.00	34.457	45.169	27.636	5.356
600.00	36.681	50.302	28.701	8.173
700.00	38.955	54.806	29.757	11.096
800.00	41.193	58.848	30.809	14.124
900.00	43.362	62.537	31.858	17.258
1000.00	45.452	65.948	32.905	20.496
1100.00	47.462	69.133	33.952	23.839
1200.00	49.394	72.132	34.997	27.286
1300.00	52.410	90.030	36.200	48.906
1400.00	55.194	92.713	36.200	52.526
1500.00	57.780	95.210	36.200	56.146
1600.00	60.193	97.547	36.200	59.766
1700.00	62.455	99.741	36.200	63.386
1800.00	64.585	101.810	36.200	67.006
1900.00	66.596	103.768	36.200	70.626
2000.00	68.501	105.624	36.200	74.246
2100.00	70.311	107.391	36.200	77.866
2200.00	72.035	109.075	36.200	81.486
2300.00	73.681	110.684	36.200	85.106
2400.00	75.255	112.224	36.200	88.726
2500.00	76.764	113.702	36.200	92.346
2600.00	78.212	115.122	36.200	95.966
2700.00	79.604	116.488	36.200	99.586
2800.00	80.945	117.805	36.200	103.206
2900.00	82.238	119.075	36.200	106.826
3000.00	83.487	120.302	36.200	110.446
3100.00	84.694	121.489	36.200	114.066
3200.00	85.862	122.638	36.200	117.686
3300.00	86.993	123.752	36.200	121.306
3400.00	88.090	124.833	36.200	124.926
3500.00	89.155	125.882	36.200	128.546
3600.00	90.189	126.902	36.200	132.166
3700.00	91.195	127.894	36.200	135.786
3800.00	92.174	128.859	36.200	139.406
3900.00	93.126	129.800	36.200	143.026
4000.00	94.055	130.716	36.200	146.646
4100.00	94.960	131.610	36.200	150.266
4200.00	95.843	132.482	36.200	153.886
4300.00	96.705	133.334	36.200	157.506
4400.00	97.547	134.167	36.200	161.126
4500.00	98.370	134.980	36.200	164.746
4600.00	99.174	135.776	36.200	168.366
4700.00	99.961	136.554	36.200	171.986
4800.00	100.732	137.316	36.200	175.606
4900.00	101.486	138.063	36.200	179.226
5000.00	102.225	138.794	36.200	182.846
5100.00	102.949	139.511	36.200	186.466
5200.00	103.659	140.214	36.200	190.086
5300.00	104.355	140.903	36.200	193.706
5400.00	105.038	141.580	36.200	197.326
5500.00	105.709	142.244	36.200	200.946
5600.00	106.367	142.897	36.200	204.566
5700.00	107.013	143.537	36.200	208.186
5800.00	107.649	144.167	36.200	211.806
5900.00	108.273	144.786	36.200	215.426
6000.00	108.886	145.394	36.200	219.046

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfOCl(g)

ΔH°_{f298} = -59.0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	58.214	68.714	12.792	0
300.00	58.214	68.293	12.836	.024
400.00	58.725	72.070	13.439	1.338
500.00	59.708	75.116	13.848	2.734
600.00	70.878	77.666	14.117	4.133
700.00	71.965	79.857	14.299	5.525
800.00	73.074	81.775	14.427	6.951
900.00	74.137	83.480	14.519	8.439
1000.00	75.149	85.014	14.587	9.954
1100.00	76.110	86.407	14.639	11.326
1200.00	77.022	87.682	14.690	12.792
1300.00	77.888	88.858	14.711	14.251
1400.00	78.711	89.950	14.737	15.734
1500.00	79.495	90.967	14.758	17.239
1600.00	80.242	91.920	14.775	18.635
1700.00	80.955	92.816	14.790	20.154
1800.00	81.638	93.662	14.802	21.663
1900.00	82.292	94.463	14.812	23.124
2000.00	82.920	95.222	14.821	24.635
2100.00	83.523	95.946	14.828	26.098
2200.00	84.103	96.636	14.835	27.571
2300.00	84.663	97.295	14.841	29.055
2400.00	85.202	97.927	14.846	30.539
2500.00	85.724	98.533	14.850	32.024
2600.00	86.228	99.116	14.854	33.509
2700.00	86.715	99.676	14.858	34.995
2800.00	87.188	100.217	14.861	36.481
2900.00	87.646	100.738	14.864	37.967
3000.00	88.091	101.242	14.867	39.454
3100.00	88.523	101.730	14.869	40.940
3200.00	88.943	102.202	14.871	42.427
3300.00	89.352	102.660	14.873	43.915
3400.00	89.750	103.104	14.875	45.402
3500.00	90.138	103.535	14.875	46.890
3600.00	90.516	103.954	14.878	48.377
3700.00	90.884	104.362	14.879	49.865
3800.00	91.244	104.758	14.881	51.353
3900.00	91.596	105.145	14.882	52.841
4000.00	91.939	105.522	14.883	54.330
4100.00	92.275	105.889	14.884	55.818
4200.00	92.603	106.248	14.885	57.306
4300.00	92.925	106.598	14.886	58.795
4400.00	93.240	106.940	14.887	60.283
4500.00	93.548	107.275	14.887	61.772
4600.00	93.850	107.602	14.888	63.261
4700.00	94.146	107.922	14.889	64.750
4800.00	94.436	108.236	14.889	66.239
4900.00	94.721	108.543	14.890	67.728
5000.00	95.000	108.844	14.890	69.217
5100.00	95.275	109.138	14.891	70.706
5200.00	95.544	109.428	14.892	72.195
5300.00	95.809	109.711	14.892	73.684
5400.00	96.069	109.990	14.892	75.173
5500.00	96.324	110.263	14.893	76.663
5600.00	96.576	110.531	14.893	78.152
5700.00	96.823	110.795	14.894	79.641
5800.00	97.066	111.054	14.894	81.131
5900.00	97.305	111.308	14.894	82.620
6000.00	97.541	111.559	14.895	84.109

Ford Motor Company
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfOF(g)

ΔH^{o}_{f298} = -109.0 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	55.760	65.760	12.235	0
300.00	55.760	65.835	12.223	.023
400.00	56.250	69.469	13.026	1.298
500.00	57.200	72.437	13.552	2.518
600.00	58.286	74.940	13.898	3.932
700.00	59.395	77.101	14.132	5.396
800.00	70.479	78.999	14.295	6.916
900.00	71.522	80.690	14.413	8.252
1000.00	72.516	82.214	14.501	9.638
1100.00	73.461	83.599	14.567	11.151
1200.00	74.360	84.869	14.618	12.611
1300.00	75.214	86.040	14.659	14.075
1400.00	76.026	87.128	14.692	15.562
1500.00	76.801	88.143	14.718	17.013
1600.00	77.540	89.093	14.740	18.636
1700.00	78.246	89.987	14.758	19.951
1800.00	78.922	90.831	14.774	21.437
1900.00	79.570	91.631	14.787	22.915
2000.00	80.192	92.389	14.798	24.395
2100.00	80.790	93.112	14.808	25.875
2200.00	81.366	93.801	14.816	27.356
2300.00	81.921	94.459	14.824	28.838
2400.00	82.457	95.090	14.830	30.321
2500.00	82.974	95.696	14.836	31.804
2600.00	83.475	96.278	14.841	33.288
2700.00	83.959	96.838	14.845	34.772
2800.00	84.429	97.378	14.850	36.257
2900.00	84.885	97.899	14.853	37.742
3000.00	85.327	98.403	14.857	39.228
3100.00	85.757	98.890	14.860	40.714
3200.00	86.174	99.362	14.862	42.200
3300.00	86.581	99.819	14.865	43.686
3400.00	86.977	100.263	14.867	45.173
3500.00	87.363	100.694	14.869	46.659
3600.00	87.739	101.113	14.871	48.146
3700.00	88.106	101.520	14.873	49.634
3800.00	88.464	101.917	14.874	51.121
3900.00	88.814	102.303	14.876	52.608
4000.00	89.156	102.680	14.877	54.096
4100.00	89.490	103.047	14.878	55.584
4200.00	89.817	103.406	14.880	57.072
4300.00	90.137	103.756	14.881	58.560
4400.00	90.451	104.098	14.882	60.048
4500.00	90.758	104.433	14.883	61.536
4600.00	91.059	104.760	14.884	63.024
4700.00	91.354	105.080	14.885	64.513
4800.00	91.643	105.393	14.885	66.001
4900.00	91.927	105.700	14.886	67.490
5000.00	92.205	106.001	14.887	68.979
5100.00	92.479	106.296	14.887	70.467
5200.00	92.747	106.585	14.888	71.956
5300.00	93.011	106.868	14.889	73.445
5400.00	93.270	107.147	14.889	74.934
5500.00	93.525	107.420	14.890	76.423
5600.00	93.775	107.688	14.890	77.912
5700.00	94.022	107.952	14.891	79.401
5800.00	94.264	108.211	14.891	80.890
5900.00	94.503	108.465	14.892	82.379
6000.00	94.737	108.716	14.892	83.868

THERMODYNAMIC FUNCTIONS OF $HfOCl_2(s)$

$\Delta H^{\circ}_{f298} = -149$ KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	79.282	79.282	17.075	0
300.00	79.282	79.387	17.097	.032
400.00	79.965	84.443	18.010	1.791
500.00	81.282	88.525	18.557	3.622
600.00	82.781	91.941	18.903	5.496
700.00	84.304	94.873	19.133	7.398
800.00	85.789	97.439	19.292	9.320
900.00	87.213	99.718	19.405	11.255
1000.00	88.567	101.767	19.489	13.200
1100.00	89.853	103.628	19.552	15.152
1200.00	91.073	105.331	19.601	17.110
1300.00	92.231	106.902	19.640	19.072
1400.00	93.332	108.359	19.671	21.038
1500.00	94.379	109.717	19.696	23.006
1600.00	95.378	110.989	19.717	24.977
1700.00	96.332	112.184	19.734	26.950
1800.00	97.244	113.313	19.749	28.924
1900.00	98.118	114.381	19.761	30.899
2000.00	98.957	115.395	19.772	32.876
2100.00	99.763	116.360	19.781	34.854
2200.00	100.538	117.280	19.789	36.832
2300.00	101.285	118.160	19.796	38.811
2400.00	102.006	119.003	19.802	40.791
2500.00	102.702	119.811	19.808	42.772
2600.00	103.375	120.588	19.812	44.753
2700.00	104.027	121.336	19.817	46.734
2800.00	104.658	122.057	19.821	48.716
2900.00	105.270	122.752	19.824	50.698
3000.00	105.864	123.424	19.827	52.681
3100.00	106.441	124.074	19.830	54.664
3200.00	107.002	124.704	19.833	56.647
3300.00	107.548	125.314	19.835	58.630
3400.00	108.079	125.906	19.837	60.614
3500.00	108.596	126.482	19.839	62.598
3600.00	109.101	127.040	19.841	64.582
3700.00	109.593	127.584	19.842	66.566
3800.00	110.074	128.113	19.844	68.550
3900.00	110.543	128.629	19.845	70.535
4000.00	111.001	129.131	19.847	72.519
4100.00	111.450	129.621	19.848	74.504
4200.00	111.888	130.100	19.849	76.489
4300.00	112.317	130.567	19.850	78.474
4400.00	112.737	131.023	19.851	80.459
4500.00	113.148	131.469	19.852	82.444
4600.00	113.551	131.905	19.853	84.429
4700.00	113.946	132.332	19.854	86.415
4800.00	114.334	132.750	19.854	88.400
4900.00	114.714	133.160	19.855	90.386
5000.00	115.087	133.561	19.856	92.371
5100.00	115.453	133.954	19.856	94.357
5200.00	115.812	134.340	19.857	96.342
5300.00	116.165	134.718	19.858	98.328
5400.00	116.512	135.089	19.858	100.314
5500.00	116.854	135.453	19.859	102.300
5600.00	117.189	135.811	19.859	104.286
5700.00	117.519	136.163	19.860	106.272
5800.00	117.843	136.508	19.860	108.258
5900.00	118.162	136.848	19.860	110.244
6000.00	118.477	137.181	19.861	112.230

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF $HfOF_2(g)$

ΔH^{o}_{f298} = -248 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	74.253	74.253	15.718	0
300.00	74.254	74.351	15.749	.029
400.00	74.889	79.079	17.081	1.676
500.00	76.129	82.986	17.902	3.428
600.00	77.555	86.300	18.424	5.247
700.00	79.014	89.167	18.769	7.107
800.00	80.444	91.690	19.007	8.997
900.00	81.821	93.939	19.177	10.906
1000.00	83.136	95.966	19.302	12.831
1100.00	84.387	97.811	19.397	14.766
1200.00	85.577	99.502	19.470	16.709
1300.00	86.709	101.062	19.528	18.659
1400.00	87.787	102.511	19.574	20.615
1500.00	88.814	103.863	19.611	22.574
1600.00	89.794	105.130	19.642	24.537
1700.00	90.732	106.321	19.668	26.502
1800.00	91.629	107.446	19.690	28.470
1900.00	92.490	108.511	19.708	30.440
2000.00	93.317	109.522	19.724	32.411
2100.00	94.111	110.485	19.737	34.385
2200.00	94.877	111.404	19.749	36.359
2300.00	95.615	112.282	19.760	38.334
2400.00	96.327	113.123	19.769	40.311
2500.00	97.015	113.930	19.777	42.288
2600.00	97.680	114.706	19.784	44.266
2700.00	98.325	115.453	19.790	46.245
2800.00	98.949	116.172	19.796	48.224
2900.00	99.555	116.867	19.801	50.204
3000.00	100.144	117.538	19.806	52.184
3100.00	100.715	118.188	19.810	54.165
3200.00	101.271	118.817	19.814	56.146
3300.00	101.812	119.427	19.817	58.128
3400.00	102.339	120.018	19.820	60.110
3500.00	102.852	120.593	19.823	62.092
3600.00	103.353	121.151	19.826	64.074
3700.00	103.841	121.695	19.828	66.057
3800.00	104.318	122.223	19.831	68.040
3900.00	104.784	122.739	19.833	70.023
4000.00	105.239	123.241	19.835	72.006
4100.00	105.684	123.730	19.836	73.990
4200.00	106.120	124.208	19.838	75.974
4300.00	106.546	124.675	19.840	77.958
4400.00	106.963	125.131	19.841	79.942
4500.00	107.372	125.577	19.842	81.926
4600.00	107.772	126.013	19.844	83.910
4700.00	108.165	126.440	19.845	85.895
4800.00	108.550	126.858	19.846	87.879
4900.00	108.928	127.267	19.847	89.864
5000.00	109.299	127.668	19.848	91.848
5100.00	109.663	128.061	19.849	93.833
5200.00	110.020	128.447	19.850	95.818
5300.00	110.371	128.825	19.851	97.803
5400.00	110.717	129.196	19.851	99.788
5500.00	111.056	129.560	19.852	101.774
5600.00	111.389	129.918	19.853	103.759
5700.00	111.718	130.269	19.854	105.744
5800.00	112.040	130.614	19.854	107.730
5900.00	112.358	130.954	19.855	109.715
6000.00	112.671	131.288	19.855	111.700

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfB_2/c

ΔH°_{f298} = -74.2 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^T_{298} (kcal/mole)
298.15	9.950	9.950	9.331	0
300.00	9.950	10.008	9.441	.017
400.00	10.393	13.499	14.355	1.262
500.00	11.366	16.973	16.615	2.804
600.00	12.568	20.120	17.831	4.532
700.00	13.851	22.928	18.554	6.354
800.00	15.145	25.437	19.015	8.234
900.00	16.416	27.696	19.322	10.152
1000.00	17.648	29.743	19.535	12.095
1100.00	18.834	31.613	19.686	14.057
1200.00	19.971	33.331	19.794	16.031
1300.00	21.061	34.918	19.873	18.014
1400.00	22.104	36.393	19.930	20.005
1500.00	23.103	37.770	19.971	22.000
1600.00	24.060	39.060	20.001	23.999
1700.00	24.979	40.273	20.023	25.000
1800.00	25.861	41.417	20.033	28.002
1900.00	26.708	42.501	20.039	30.006
2000.00	27.524	43.529	20.041	32.010
2100.00	28.309	44.508	20.134	34.017
2200.00	29.067	45.445	20.157	36.031
2300.00	29.799	46.343	20.230	38.051
2400.00	30.506	47.205	20.293	40.077
2500.00	31.191	48.035	20.356	42.109
2600.00	31.854	48.834	20.420	44.148
2700.00	32.497	49.606	20.483	46.193
2800.00	33.122	50.352	20.546	48.245
2900.00	33.728	51.074	20.609	50.303
3000.00	34.318	51.774	20.672	52.367
3100.00	34.892	52.453	20.735	54.437
3200.00	35.452	53.112	20.798	56.514
3300.00	35.997	53.753	20.851	58.597
3400.00	36.528	54.377	20.924	60.686
3500.00	37.047	54.984	20.987	62.781
3600.00	37.720	63.076	21.000	91.281
3700.00	38.413	63.651	21.000	93.381
3800.00	39.085	64.211	21.000	95.481
3900.00	39.736	64.757	21.000	97.581
4000.00	40.368	65.288	21.000	99.681
4100.00	40.982	65.807	21.000	101.781
4200.00	41.579	66.313	21.000	103.881
4300.00	42.160	66.807	21.000	105.981
4400.00	42.726	67.290	21.000	108.081
4500.00	43.277	67.762	21.000	110.181
4600.00	43.814	68.223	21.000	112.281
4700.00	44.339	68.675	21.000	114.381
4800.00	44.850	69.117	21.000	116.481
4900.00	45.350	69.550	21.000	118.581
5000.00	45.838	69.974	21.000	120.681
5100.00	46.315	70.390	21.000	122.781
5200.00	46.782	70.798	21.000	124.881
5300.00	47.239	71.198	21.000	126.981
5400.00	47.687	71.591	21.000	129.081
5500.00	48.125	71.976	21.000	131.181
5600.00	48.554	72.354	21.000	133.281
5700.00	48.975	72.726	21.000	135.381
5800.00	49.388	73.091	21.000	137.481
5900.00	49.792	73.450	21.000	139.581
6000.00	50.190	73.803	21.000	141.681

Ford Motor Company,
AERONUTRONIC DIVISION

THERMODYNAMIC FUNCTIONS OF HfC/c

ΔH^{o}_{f298} = -44.7 KCAL/MOLE

T (°K)	$(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	10.900	10.900	9.147	0
300.00	10.900	10.957	9.154	.017
400.00	11.264	13.639	9.507	.950
500.00	11.961	15.797	9.840	1.918
600.00	12.756	17.619	10.165	2.918
700.00	13.567	19.211	10.487	3.951
800.00	14.363	20.632	10.806	5.015
900.00	15.132	21.923	11.125	6.112
1000.00	15.871	23.111	11.442	7.240
1100.00	16.580	24.217	11.760	8.400
1200.00	17.260	25.254	12.077	9.592
1300.00	17.913	26.233	12.394	10.816
1400.00	18.541	27.163	12.710	12.071
1500.00	19.146	28.051	13.027	13.358
1600.00	19.729	28.901	13.343	14.676
1700.00	20.293	29.720	13.659	16.026
1800.00	20.838	30.510	13.976	17.408
1900.00	21.368	31.274	14.292	18.821
2000.00	21.882	32.015	14.608	20.266
2100.00	22.381	32.728	14.610	21.727
2200.00	22.867	33.407	14.610	23.188
2300.00	23.340	34.057	14.610	24.649
2400.00	23.799	34.678	14.610	26.110
2500.00	24.246	35.275	14.610	27.571
2600.00	24.682	35.848	14.610	29.032
2700.00	25.105	36.399	14.610	30.493
2800.00	25.518	36.931	14.610	31.954
2900.00	25.921	37.443	14.610	33.415
3000.00	26.313	37.939	14.610	34.876
3100.00	26.696	38.418	14.610	36.337
3200.00	27.070	38.882	14.610	37.798
3300.00	27.434	39.331	14.610	39.259
3400.00	27.791	39.767	14.610	40.720
3500.00	28.139	40.191	14.610	42.181
3600.00	28.479	40.602	14.610	43.642
3700.00	28.813	41.003	14.610	45.103
3800.00	29.138	41.392	14.610	46.564
3900.00	29.458	41.772	14.610	48.025
4000.00	29.770	42.142	14.610	49.486
4100.00	30.076	42.502	14.610	50.947
4200.00	30.424	47.854	14.610	73.208
4300.00	30.833	48.198	14.610	74.669
4400.00	31.232	48.534	14.610	76.130
4500.00	31.620	48.862	14.610	77.591
4600.00	31.998	49.184	14.610	79.052
4700.00	32.367	49.498	14.610	80.513
4800.00	32.727	49.805	14.610	81.974
4900.00	33.079	50.107	14.610	83.435
5000.00	33.423	50.402	14.610	84.896
5100.00	33.758	50.691	14.610	86.357
5200.00	34.087	50.975	14.610	87.818
5300.00	34.408	51.253	14.610	89.279
5400.00	34.722	51.526	14.610	90.740
5500.00	35.030	51.794	14.610	92.201
5600.00	35.332	52.058	14.610	93.662
5700.00	35.628	52.316	14.610	95.123
5800.00	35.918	52.570	14.610	96.584
5900.00	36.202	52.820	14.610	98.045
6000.00	36.481	53.066	14.610	99.506

THERMODYNAMIC FUNCTIONS OF HfN/c

ΔH^{o}_{f298} = -88.24 KCAL/MOLE

T (°K)	$-(F-H_{298})/T$ (cal/mole °K)	S (cal/mole °K)	C_p (cal/mole °K)	H^{T}_{298} (kcal/mole)
298.15	10.910	10.910	10.457	0
300.00	10.910	10.975	10.462	.019
400.00	11.324	14.020	10.717	1.079
500.00	12.113	16.437	10.953	2.162
600.00	13.006	18.454	11.181	3.269
700.00	13.912	20.195	11.405	4.398
800.00	14.795	21.732	11.628	5.550
900.00	15.644	23.114	11.849	6.724
1000.00	16.455	24.374	12.069	7.920
1100.00	17.228	25.535	12.290	9.138
1200.00	17.966	26.614	12.509	10.377
1300.00	18.670	27.624	12.729	11.639
1400.00	19.344	28.575	12.948	12.923
1500.00	19.990	29.476	13.168	14.229
1600.00	20.610	30.333	13.387	15.557
1700.00	21.206	31.151	13.606	16.906
1800.00	21.780	31.935	13.825	18.278
1900.00	22.335	32.688	14.044	19.671
2000.00	22.871	33.414	14.263	21.087
2100.00	23.389	34.110	14.270	22.514
2200.00	23.892	34.774	14.270	23.941
2300.00	24.379	35.408	14.270	25.368
2400.00	24.851	36.016	14.270	26.795
2500.00	25.309	36.598	14.270	28.222
2600.00	25.755	37.158	14.270	29.649
2700.00	26.187	37.696	14.270	31.076
2800.00	26.607	38.215	14.270	32.503
2900.00	27.016	38.716	14.270	33.930
3000.00	27.414	39.200	14.270	35.357
3100.00	27.802	39.668	14.270	36.784
3200.00	28.180	40.121	14.270	38.211
3300.00	28.549	40.560	14.270	39.638
3400.00	28.908	40.986	14.270	41.065
3500.00	29.259	41.400	14.270	42.492
3600.00	29.630	46.802	14,270	61.819
3700.00	30.099	47.193	14.270	63.246
3800.00	30.554	47.573	14.270	64.673
3900.00	30.995	47.944	14.270	66.100
4000.00	31.423	48.305	14.270	67.527
4100.00	31.840	48.658	14.270	68.954
4200.00	32.244	49.001	14.270	70.381
4300.00	32.638	49.337	14.270	71.808
4400.00	33.021	49.665	14.270	73.235
4500.00	33.394	49.986	14.270	74.662
4600.00	33.759	50.300	14.270	76.089
4700.00	34.114	50.606	14.270	77.516
4800.00	34.460	50.907	14.270	78.943
4900.00	34.799	51.201	14.270	80.370
5000.00	35.130	51.489	14.270	81.797
5100.00	35.454	51.772	14.270	83.224
5200.00	35.770	52.049	14.270	84.651
5300.00	36.080	52.321	14.270	86.078
5400.00	36.383	52.588	14.270	87.505
5500.00	36.680	52.850	14.270	88.932
5600.00	36.971	53.107	14.270	90.359
5700.00	37.256	53.359	14.270	91.786
5800.00	37.536	53.607	14.270	93.213
5900.00	37.811	53.851	14.270	94.640
6000.00	38.080	54.091	14.270	96.067

REFERENCES

1. JANAF Interim Thermochemical Tables, The Dow Chemical Company, Midland, Michigan, December 31, 1960.

2. Aeronutronic Publications Numbered U-1835, C-1960, Vol. I, and U-2045.

3. Stull, D. R. and Sinke, G. C., Thermodynamic Properties of the Elements, A.C.S. Monograph No. 18 (1956).

4. Barriault, R. J., et al., Thermodynamics of Certain Refractory Compounds, ASD Technical Report 61-260, Part 1 under Contract AF33(616)-7327. Research and Advanced Development Division, Avco Corporation, October 31, 1961.

5. Ingrham, M. G., Chupka, W. A., and Berkowitz, J., J. Chem. Phys., 27, 569 (1957).

6. Brewer, J. and Chandrasekharaiah, M. S., Report UCRL-8713, Lawrence Radiation Laboratory, Contract No. W-7405-eng48 (1959).

7. Study of Metal Additives for Solid Propellants, Twelfth Quarterly Report under Contract NOrd 17980. Aeronutronic Division of Ford Motor Company, Publication No. C-1010, October 15, 1960 (CONFIDENTIAL).

8 Bartlett, E. P., A Systematic Method for Determination of Ablation Rates in a Corrosive Environment. Paper presented at the Sixth Symposium on Ballistic Missile and Aerospace Technology in Los Angeles (1961).

9. Humprey, G. L., J. Amer. Chem. Soc., 76, 978 (1954).

10. Kelley, K. K. and King, E. G., Bulletin 592, Bureau of Mines (1961).

11. Orr, R. L., J. Amer. Chem. Soc., 75, 2808 (1953).

12. Somayajulu, G. R., J. Chem. Phys., _, 1541 (1960).

13. Bowen, J. J. M., et al, Tables of Interatomic Distances and Configuration in Molecules and Ions, London: Chemical Society, Special Publication No. 11 (1958).

14. Varshni, Y. P., J. Chem. Phys., 28, 1078 (1958).

15. Herzberg, G., Molecular Spectra and Molecular Structure, II. Infrared and Raman Spectra of Polyatomic Molecules, D. Van Nostrand Company, New York (1945).

16. von Schafer, H. and Kahlenberg, F., Z. Anorg. U. Allgemo, Chem., 305, 178 (1960).

17. Shomate, G. H., J. Phys. Chem., 58, 368 (1954).

18. Huber, Jr., E., Head, E. L., Holley Jr., C. E. and Bownan, A. L., The Heats of Formation of Tantalum Carbides and Oxides, Los Alamos Scientific Labs., to be published.

19. Humphrey, G. L., JACS, 76, 978 (1954).

20. Kelley, K. K., Contributions to the Data on Theoretical Metallurgy. XIII High-Temperature Heat Content, Heat Capacity, and Entropy Data for the Elements and Inorganic Compounds, U. S. Bureau of Mines Bulletin 584, 1960.

21. Mezaki, R., Heat Contents of Inorganic Substances at High Temperatures, Thesis under J. L. Margrave, University of Wisconsin, 1961.

22. NBS 500, Selected Values of Chemical Thermodynamic Properties.

23. Zalabak, C. F., The Melting Points of Tantalum Carbide and of Tungsten, Technical Note D-761 NASA, March 1961.

24. Schwarzkopf, P. and Kiefer, R., Refractory Hard Metals, Borides Carbides, Nitrides, and Silicides, MacMillan, New York, 1953.

25. Ellinger, F. H., Trans. ASM, 31, 89 (1943).

26. Kubaschewski, O. L. and Evans, E., Metallurgical Thermochemistry, Program Press, 1958.

27. Neel, D. S., Pears, C. D., Oglesby, Jr., S., The Thermal Properties of Thirteen Solid Materials to 5000°F or their Destruction Temperature, WADD TR 60-924, February 1962.

28. Mah, A. D. and Gilbert, N. L., JACS, 80, 3812 (1956).

29. Brewer, L. and Haraldsen, H., J. Electrochem. Soc., 102, 399-406 (1955).

30. Leitnaker, J. M., Thermodynamic Properties of Refractory Borides, LA-2402 Los Alamos, January 1960. Also, Leitnaker, J. M. and Bowman, M. G., J. Chem. Phys., 36, 350 (1962).

31. Miller, G. L., Tantalum and Niobium, p. 734, Academic Press, New York, 1959.

32. Samsonov, G. V., Zh. Fiz. Khim (1956) 2057.

33. Lowrie, R., Research on Physical and Chemical Principles Affecting High Temperature Materials for Rocket Nozzles, Union Carbide, QPR December 31, 1962, ARPA Order 34-62.

34. Margrave, J. L., Mezaki, R., Tilleux, E. W., and Barnes, D. W., Thermodynamic Properties of Inorganic Substances vs. High Temperature Heat Contents of Filter Refractory Borides, University of Wisconsin, 1962.

35. Westrum, Jr., G. and Fleick, E. F., Zirconium Diboride: The Heat Capacity and Thermodynamic Properties from 5 to 350°K, Contract AF33(616) 7422.

36. Aronson, B., Borides, Part A. Basic Factors in Modern Materials, Vol. 2, 1960, Academic Press, New York, edited by H. H. Hausner.

37. Study of Metal Additives for Solid Propellants, Twelfth Quarterly Report, Contract NOrd 17980. Aeronutronic Division of Ford Motor Company, Publication No. C-1010, October 15, 1960 (CONFIDENTIAL).

38. von Schafer, H. and Sibbing, E., Z. Anorg, U. Allgeim. Chem., 305 341 (1960).

39. Pitzer, K. S. and Brewer, L., Thermodynamics (revised Second Edition of Lewis and Randall), McGraw-Hill, New York (1961).

40. Sara, R. V. and Dolloff, R. T., Research Study to Determine the Phase Equilibria of Selected Metal Carbides at High Temperatures, National Carbon Company, WADD TR 60-143, Part III, April 1962.

41. McGraw, L. D., Seltz, H. and Snyder, P. E., JACS 69, 329 (1947).

42. Poland, D. E., Green, J. W., and Margrave, J. L., Ideal Gas Thermodynamic Functions of Some Selected Elements, Journal of Chemical and Engineering Data, 7, 389-90 (1962).

43. Kelley, K. K. amd King, E. G., Thermodynamic Properties of Hafnium and its Compounds, Chapter 9 in The Metallurgy of Hafnium, Thomas and Hayes, (editors), USAEC, Division of Reactor Development (1960).

44. Brewer, L., and Chandrasekharaiah, M. S., Free Energy Functions for Gaseous Monoxides, UCRL-8713, Berkeley, California (April, 1959).

45. Chandrasekharaiah, M. S., and Brewer, L., Free Energy Functions for Some MO_2 Oxides, UCRL-8736, Berkeley, California (April, 1959).

46. Goldsmith, A., Waterman, T. E., and Hirschhorn, H. J., Handbook of Thermophysical Properties of Solid Materials, Volume I: Elements Armour Research Foundation, The Macmillan, Co., New York (1961).

47. Orr, R. L., High Temperature Heat Contents of Hafnium Dioxide and Hafnium Tetrachloride, JACS, 75, 1231-2 (1953).

48. Buchler, A., Berkowitz-Mattuck, J. B., and Dugre, D. H., Infrared Spectra of Some Group IV Halides, Journal Chem. Phys., 34, 2202-3 (1961).

49. Gordy, W., A Relation Between Bond Force Constants, Bond Orders, Bond Lengths, and the Electronegativities of the Bonded Atoms, Journ. Chem. Phys., 14. 305-320 (1946).

50. Gross, P., Fulmer Reserach Institute, private communication, May 1962.

51. Palko, A. A., Ryon, A. D. and Kuhn, D. W., The Vapor Pressures of Zirconium Tetrachloride and Hafnium Tetrachloride, J. Phys. Chem., 62, 319-22 (1958).

52. Greenberg, E., Settle, J. L., and Hubbard, W. N., Fluorine Bomb Calorimetry. IV. The Heats of Formation of Titanium and Hafnium Tetrafluorides, J. Phys. Che., 66, 1345 (1962).

53. Kaylor, C. E., Walden, G. E., and Smith, D. F., High Temperature Heat Content and Entropies of Hafnium Tetrafluoride and Rubidium Fluoride, JACS, 81, 4172-3 (1959).

54. Panish, M. B. and Reif, L., Thermodynamics of the Vaporization of HF and HfO_2: Dissociation Energy of HfO, Journal of Chem. Phys. 38. 253-6 (1963).

55. Paderno, Y. B., Serebryakova, T. I. and Samsonov, G. V., Production and Certain Properties of Hafnium Boride, Tsvetnye Metally, 32, No. 11, 48-50 (1959).

56. Agte, C. and Alterthum, H., Z. Tech. Physik, 11, 182 (1930).

57. Humphrey, G. L., J. Amer. Chem. Soc., 75, 2806 (1953).

58. Boosz, J. H., Metall. 11, 22-3 (1957) (CA 51, 6308a)